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47.

MEMOIRS OF THE GEOLOGICAL SURVEY.

ENGLAND AND WALES.

THE

GEOLOGY OF THE N.W. PART OF ESSEX AND THE N.E. PART OF HERTS.

WITH

PARTS OF CAMBRIDGESHIRE AND SUFFOLK.

(EXPLANATION OF SHEET 47 OF THE MAP (ONE-INCH) OF THE
GEOLOGICAL SURVEY OF ENGLAND AND WALES.)

BY

W. WHITAKER, B.A., F.G.S., W. H. PENNING, F.G.S.,
W. H. DALTON, F.G.S.; AND F. J. BENNETT, F.G.S.

PUBLISHED BY ORDER OF THE LORDS COMMISSIONERS OF HER MAJESTY'S TREASURY.

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NOTICE.

In the following Memoir the Authors have described all the formations mapped in Sheet 47 including the Cretaceous strata from the Gault to the Upper Chalk, the Eocene beds from the Thanet Sand to the London Clay, the Red Crag, and the Glacial deposits of Boulder Clay and gravels and sands. The area described includes parts of Essex, Herts, Cambridgeshire, and Suffolk, and the illustrative wood-cuts, and detailed Sections will be useful for reference long after some of the actual sections have become obscured or have altogether disappeared. The Appendix of Well-sections to all persons interested in water supply forms an important feature of the Memoir.

ANDW. RAMSAY,
Director-General.

November 22, 1878.

G 383. Wt. B 1029.

NOTICE.

THE district described in this Memoir was surveyed, under the superintendence of MR. WHITAKER, by himself and the following colleagues:—MR. W. H. PENNING (more than half the map, from the neighbourhood of Royston on the N.W. to that of Clare on the N.E., and of Harlow on the S.); MR. W. H. DALTON (the neighbourhoods of Witham and Coggeshall, forming the S.E. part of the map); and MR. F. J. BENNETT (separate areas in the neighbourhoods of Buntingford, Dunmow, and Halstead).

MR. WHITAKER is himself answerable for the S.W. and N.E. corners, in the neighbourhoods of Hertford and of Sudbury, the latter of which, though small, involved much detail.

MR. C. E. HAWKINS mapped a few square miles near Cavendish.

Whilst each observer has described his own ground, the arrangement and editing of the whole Memoir, with the addition of some general remarks and occasional details, has been entrusted to Mr. WHITAKER.

The lists of fossils have been revised by MR. ETHERIDGE.

The description of the Eocene beds of the western part, from Hertford to Stortford, is reproduced, with additions and corrections, from Vol. iv. of the *Geological Survey Memoirs* (1872).

H. W. BRISTOW,
Senior Director.

Geological Survey Office,
28, Jermyn Street, S.W.,
November, 1878.

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* These are from the Quarterly Journal of the Geological Society.
† These are from Vol. iv. of the Memoirs of the Geological Survey (1872).

THE
GEOLOGY
OF THE
N.W. PART OF ESSEX AND THE N.E. PART OF HERTS,
ETC.

CHAPTER I.—INTRODUCTION.

AREA.

Sheet 47 of the Geological Survey Map represents an area of about 840 square miles, chiefly in *Essex* (with the towns of Braintree, Coggeshall, Dunmow, Halstead, Saffron Walden, Thaxted, and Witham), but partly in *Hertfordshire* (Bishop's Stortford, Buntingford, Hertford, and Ware), partly in *Cambridgeshire* (Linton and Royston), and partly in *Suffolk* (Clare, Haverhill, Long Melford, and Sudbury). This tract forms part of the London Basin.

RIVERS.

The rivers of the district are the *Lea* (between Hertford and Hoddesdon), with the following tributaries:—the *Rib* and *Quin* which, rising in the neighbourhood of Buckland and Barkway, join each other at Braughing, the united stream flowing southwards into the Lea at Bengeo (Hertford); the *Ash*, rising in the neighbourhood of the Pelhams, flowing S.S.W., and joining the main stream below Ware; the *Stort*, rising near Langley, Farnham, and Elsenham, flowing S.S.W. and joining the Lea near Hoddesdon, with the tributary *Pincey Brook*, which rises north of Hatfield Forest, and joins the Stort near Harlow. The upper part of the *Roding*, which river rises westward of Dunmow, and flows southwards beyond our district. The above drain into the Thames. The *Blackwater*, 28 miles long, rising, under the name of *Pant*, near Radwinter and Finchingfield, and flowing south-eastward to Feering, thence south-westward to below Witham, and finally eastward to the sea, with the following tributaries:—the *Cann*, 11½ miles long, rising east of High Roding; the *Chelmer*, 29 miles long, rising north of Thaxted and flowing S.S.E. with a tributary stream from Lindsell; the *Ter*, 12 miles long, rising westward of Braintree, and also flowing S.S.E.; and the *Brain*, *Guith*, *With* or *Pods Brook*, 15 miles long, rising near Bardfield.

The upper part of the *Colne,* which rises near Birdbrook, with a tributary from near Gosfield. Some small streams that rise on Tiptree Heath flow eastwards and form the *Layer Brook,* a tributary to the Colne. The *Stour* (from Haverhill and Kedington, E.S.E., to below Sudbury).

All the above streams flow southwards or eastwards, but the head-waters of the *Cam* or *Granta* rising near Quendon, with the streams N. and E. of Royston, which run into its tributary the *Rhee,* and the upper part of its other tributary the *Bourn,* which rises eastward of Linton, flow northwards.

GEOLOGICAL DIVISIONS.

The beds shown on the Geological Survey Map are as in the following table, in which the right-hand column gives the divisions coloured on the map :—

Pleistocene	Recent		Alluvium.
	Post-Glacial	Valley, or Old River, Drift.	Brickearth, or loam. Gravel.
		Plateau Drift	Loam. Gravel.
	Glacial Drift		Boulder Clay. Brickearth. Gravel and sand, with occasional Boulder Clay.
	Preglacial ?		Pebble-gravel.
Pliocene			Red Crag.
Eocene			London Clay.
	Lower London Tertiaries		Reading Beds. Thanet Beds.
Cretaceous			Chalk. Gault.

Of these the Chalk, either bare or covered with Drift, takes up the north-western half, and the London Clay, still more Drift-covered, the south-eastern, the Lower London Tertiaries having but a narrow outcrop between. The various divisions of the Drift cover by far the greater part of the district, the Boulder Clay alone occurring over more than two thirds of it. The gravels and sands beneath the Boulder Clay crop out mostly along the bottoms and flanks of valleys; whilst the smaller tracts of Post-Glacial gravel, &c. in great part border the streams or their alluvial flats; but there are also patches of "plateau-gravel" that seem to be of this age, and others of loam that clearly overlies the Boulder Clay.

W. W.

SHAPE OF THE GROUND.

The highest ground within the limits of the map occurs near its northern boundary, where the range of Chalk hills slopes sharply to the north, overlooking the Cambridge Valley. Some points along this range reach a height of over 500 feet (Tharfield being 550). There is some high ground towards the centre of the district also, Thaxted being 324 feet above the sea.

Although a part of the northern slope of the range comes within the area, by far the larger part of the Cambridge Valley is beyond our limits, and will be described in a Memoir to illustrate Sheet 51, S.W.

The southern slope of the ground from the range of hills is much more gradual, and continues across the district with but little variation, except where carved out by the valleys. The range itself is in one part cut through by the valley of the Cam.

At the S.W. corner of the district, between Hertford and Hoddesdon, the London Clay, mostly covered with Boulder Clay and gravel, rises to a fair height, and at the S.E. corner the range of Tiptree Heath (London Clay, with cappings of gravel) rises above the surrounding tracts, and makes a marked feature in the landscape.

W. W. and W. H. P.

CHAPTER 2.—CRETACEOUS BEDS.

GAULT.

The Gault occupies an area of only a fraction of a square mile in the western corner of sheet 47. It consists of a stiff blue clay, about 60 feet thick, and having at its base a bed of sand 3 feet thick, which rests on a water-bearing "rock" that forms the top of the Lower Greensand. A bed of phosphatic nodules occurs a few feet up from the base of the Gault, (*see* Appendix, p. 74), and the upper surface of the clay is very uneven, having been much eroded before the deposition of the overlying Chalk.

W. H. P.

CHALK.

Although shown as one mass on the map, the Chalk may here be described under the following heads: *Chalk Marl, Lower Chalk, Chalk Rock,* and *Upper Chalk.* No attempt has been made to trace the "zones" of Professor Hébert in this district, but I have been shown by Mr. Jukes-Browne, that they can be made out to the north, in Sheet 51, and a notice of them will therefore be given in the description of that map.

W. W.

Chalk Marl.

Resting upon the eroded surface of the Gault is the bed known as the "Cambridge Greensand." It is, in reality, the glauconitic base of the Chalk Marl, into which it gradually passes; it is seldom more than a foot thick, and in this area is always found at the junction of the two formations. About one-tenth of its bulk consists of fossils and phosphatic nodules, some 75 per cent. of which have been derived from the Gault, as recorded by Mr. Jukes-Browne, who has carefully worked out the history of this bed, its fauna, and relations.*

The deposit is, as its name implies, a Marl, it is white, or rather very light grey in colour, and its thickness is about 60 feet. It is exposed in many sections near its base, where the fossiliferous bed is dug out for the phosphatic nodules, or so-called "coprolites," which it contains in such abundance.

W. H. P.

In the tract to the west the Chalk Marl is ended at top by a firm and somewhat sandy bed, known as the Totternhoe Stone; but this has not been noticed in our district, though it must occur, having been traced through the sheet to the north (51, S.W.)

W. W.

---

* *Quart. Journ. Geol. Soc.*, vol. xxxi., pp. 256–316 (1875).

Lower Chalk.

This division forms the gently-sloping ground from the escarpment to the plain of the Chalk Marl. It is shown in many sections, chiefly quarries, in the harder beds, which are sufficiently compact to be used for building purposes. There is a great similarity in the texture and position of some of these beds, indicating the possibility of identifying them over larger areas, or even of correlating them with distant deposits. And this is borne out as regards some of the beds by the fossils they contain, and by which they are recognised as the equivalents of deposits that occur in Bedfordshire, Buckinghamshire, Wiltshire, the Isle of Wight, and other places in the south of England and on the Continent.

The Lower Chalk occupies the area N. and W. of the dotted line on the map, which gives approximately the line of division between it and the Upper Chalk. Its thickness is about 300 feet, as ascertained from its outcrop and average dip, a result agreeing fairly with the recorded thickness of strata passed through in making a deep well at Saffron Walden. It has been erroneously asserted, and many calculations have been based upon the statement, that the boring for this well was entirely in Chalk. No doubt chalky matter from the upper part of the bore-hole got mixed with that brought up by the tool, and gave it a white chalky appearance, but Dr. James Mitchell has recorded that "samples at 800 feet, blue when taken out, got whitish, and by muriatic acid were found to be clay with some calcareous matter."* This would probably be true of other portions also, and the boring almost certainly went through the Gault and down into the Oxford Clay. (*See* Appendix, p. 79.)

In the chalk-pit 1¼ miles N. of Royston the following beds occur, all without flints, and dipping 4° E. :—

	FEET.
Rubbly chalk - - - -	8 or 10
Hard white chalk, in blocks - -	2
Yellow marly chalk, much broken -	2 to 3
Hard white chalk, in blocks - -	2
White chalk, broken up - - -	6

At the lime-kiln about a third of a mile S.W. of Royston there is chalk with few flints, dipping 5° S., with *Terebratula semiglobosa* and *Inoceramus;* and at the chalk-pit, ¼ mile S.E. of that town, there is white chalk, 30 feet shown, rubbly at the top, the lower part tabular, with irregular lines of bedding and one thin layer of flint nodules, thrown down 1 or 2 feet in places by small faults. Dips slightly to E. or S.E.

A pit ¾ mile W. of Meldreth Station shows 3 feet of rubbly chalk over 5 feet of hard grey chalk (? Totternhoe Stone).

At the chalk-pits S. of Melbourne the W. end of the W. pit gave the section below :—

		FEET.
White rubbly chalk	- - - -	5
Yellow „	dipping 4° W. by S. -	1
White „	- - - -	2
Tabular chalk -	- - - -	8

---

* MSS., vol. ii. p. 102. For an examination of this valuable collection I have to thank Prof. Prestwich.—W. W.

In the pit a quarter of a mile S.W. of Duxford there is white chalk with much "slickenside," and in places with a thin marly layer.

The pit half a mile E. of Great Chesterford shows 40 feet of white chalk, dipping E. 5° (?). About 18 feet from the top is a band of marl, 3 or 4 inches thick, not so light in colour as the chalk, and immediately above it some hard splintery chalk containing fossils (*Pecten*, *Terebratulina*, and *Cidaris*: the other species of the list are from below the marly band).

A layer of flints occurs 5 or 6 feet below the marl. The peculiar striated or fibrous chalk is well shown in this pit, occurring especially around many of the flints, but only where these are in a vertical or nearly vertical position. [In this case the fibrous appearance is clearly not due to slickensides, but to structure, as it is not limited to the faces of joints, &c., but extends some little way into the mass of the chalk.—W. W.] W. H. P.

Other sections of the Lower Chalk will be noticed under the next heading, and a description of the lithological divisions that can often be made out in the Lower Chalk westward of this district may be seen in Vol. IV. of the Geological Survey Memoirs, pp. 42–45.

The following list of fossils from the Lower Chalk has been compiled from separate lists furnished by Mr. Penning, the species in this and the other Chalk lists (pp. 9, 10) having been named by Mr. Etheridge.

W. W.

FOSSILS FROM THE LOWER CHALK.

—	Pit on E. side of high road about a mile N. of Royston.	Pit about a third of a mile S.E. of Royston Church.	Pit on E. side of high road nearly a mile N. of Reed.	Pit ½ mile N. of Barley.	Pit 1¼ miles W. by S. of Ickleton.	Pit just E. of Great Chesterford.
Otodus appendiculatus, *Ag.* - - -	×					
Ptychodus, tooth -	—	—	—	—	—	×
Belemnitella plena, *Blainv.* - -	×					
Scaphites æqualis, *Sby.* -	—	—	—	×	×	
Dianchora striata, *Sby.* -	—	—	—	—	—	×
Gryphæa vesiculosa ?, *Sby.*	×					
Inoceramus, *sp.* -	×	—	—	×	×	×
Lima spinosa, *Sby.* -	—	×				
Ostrea canaliculata, *Sby.*	—	—	—	—	—	×
„ vesicularis, *Lam.*	×					
„ *sp.* - -	—	—	—	—	×	
Rhynchonella Cuvieri, *D'Orb.* - -	—	—	—	×		
Rhynchonella plicatilis, *Sby.* - - -	×	—	×	×		
Terebratula semiglobosa, *Sby.* - - -	×	—	×	×	×	
Terebratula, *sp.* -	—	—	—	—	—	×
Scalpellum, *sp.* - -	—	—	—	—	—	×
Discoidea Dixoni, *Forbes*	—	×				
Goniaster, ossicle of -	—	—	—	—	×	
Holaster planus *Mant.* -	—	—	×			
Micraster cor-anguinum, *Leske* - -	—	×				
Micraster cor-bovis, *Forbes*	—	—	×			
Ventriculites impressus, *Smith* - -	—	—	—	×		
Ventriculites mammillaris, *Smith* - -	—	—	—	×		

Chalk-rock.

The Lower Chalk ends upwards in a hard crystalline bed, frequently yellow and broken up into lumps 2 or 3 inches across, with a marly substance between them ; but the latter is probably a wash into the joints from the chalk above. This bed, or rather deposit divided into two crystalline beds with soft chalk between, has been described under the name of Chalk-rock,* and is tolerably persistent from Wiltshire up to and probably far beyond this district, though, from the scarcity of sections, the outcrop cannot be accurately traced. It contains many fossils, *Holaster planus* being somewhat characteristic, and its upper limit is sharply defined ; it indicates a change in the conditions of deposit which, brief as it may or may not have been, was certainly considerable.

The Chalk-rock divides the Upper from the Lower Chalk, but not the Chalk-with-flints from that without, as sparse bands of flint nodules occur in the chalk some way below the rock. Other bands are found nearly down to the Chalk Marl, indeed it is rare to see a chalk-pit in which flints cannot be discovered.

There are to the S. of Royston a few sections of the Chalk-rock, which is not again seen eastward until we get to the chalk-pit by Great Chesterford Park. W. H. P.

These pits are interesting as showing *a dip northwards, that is, down the escarpment, or in the direction reverse to the regular dip, and gradually increasing from* 0 *to a high angle.* They are indeed along a line of flexure (*see* p. 11).

The most westerly of them is close to the top of the escarpment, a mile north of Reed, and its section is shown in Fig. 1. The next is also just below the top of the escarpment, on the western side of the road, more than half a mile northward of Barkway Church, and in it the dip increases to about 60°, being well shown by four distinct layers (hard beds, marl, and flints): this section is shown in Fig. 2. The third, only about 13 feet deep, is at the southern part of Smyth's End, just south of Barley, and gave the following section :—

Boulder Clay, in a hollow on the north.
Chalk, with flints in layers 5 feet apart, dipping N. by W. 40° to 45°.
Stained chalk just seen at the bottom at the corner, probably Chalk-rock (with *Lima spinosa* and *Terebratula semiglobosa*).

W. W. and W. H. P.

The chalk-pit a quarter of a mile S.S.E. of Great Chesterford Park shows the rock, the section being—

Chalk with flints, dipping slightly S.E.

Chalk-rock, 2–5 feet.	Yellowish crystalline chalk in lumps, in a marly matrix, a few inches to a foot. Rubbly chalk. Hard crystalline chalk, passing down into the bed below.

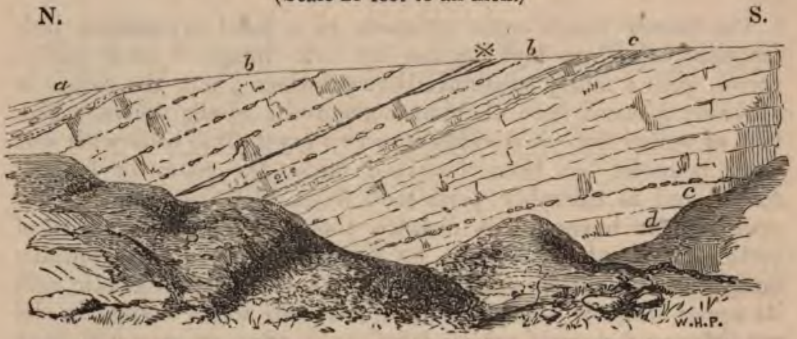
Soft tabular chalk, with few flints.

The top of the Chalk-rock is here very definite, though somewhat irregular and the bed contains many fossils and phosphatic nodules, as well as decomposed iron-pyrites. W. H. P.

---

* See *Geological Survey Memoirs*, vol. iv. p. 46.

Fig. 1.—*Section in a Chalk-pit N. of Reed.*
(Scale 25 feet to an inch.)



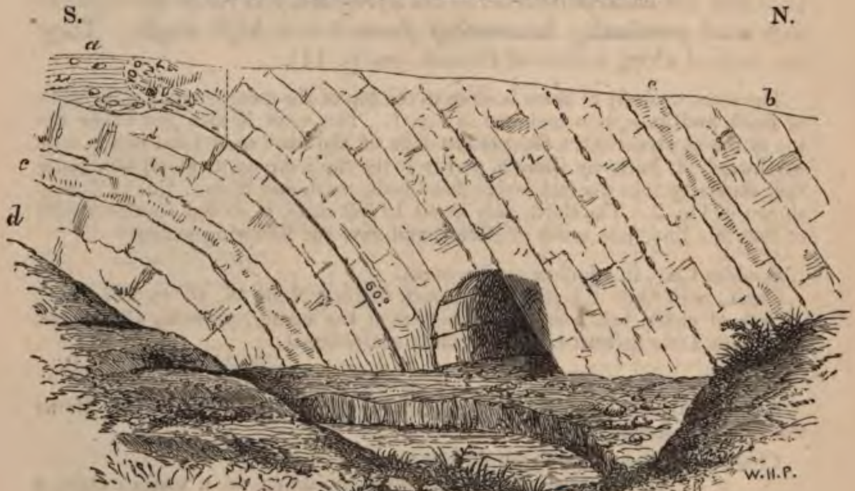
a. Boulder Clay (at one part only), with hard crystalline band beneath.

b. Upper Chalk, with layers of flints, dipping N. 21°, and a marked layer of tabular flints(*). A *Ventriculite* was the only fossil found.

c. Chalk-rock.
- Cream-coloured crystalline chalk, very fossiliferous (*see* p. 9), 2 feet.
- Hard compact chalk, 8 or 10 feet.
- Cream-coloured crystalline chalk, about 2 feet.

d. Lower Chalk; with a layer of sparse flint-nodules at top, bent over from a nearly horizontal position to an angle of 5° N.

Fig. 2.—*Section in a Chalk-pit N. of Barkway.*



a. Whitish Boulder Clay; occurs in a hollow at S.W. corner.

b. Upper Chalk, with scattered flints.

c. Chalk-rock. Hard cream-coloured crystalline chalk, irregular beds, 2 to 2½ feet thick. The chalk between with a thin layer of marl (⚹) and a broken-up layer of flint-nodules.

d. Lower Chalk. (*Inoceramus, Scalpellum,* etc.)

[When at these pits I was inclined to limit the name chalk-rock to the upper bed *c.* in Fig. 1, and to the lower in Fig. 2.—W. W.]

Fossils from the Chalk-rock.

—	Pit on E. side of high road nearly a mile N. of Reed.	Pit ½ mile northwards of Barkaway Church.	Pit 1¼ miles N.E. of Great Chesterford.
Fish teeth	—	—	×
Ammonites prosperianus, *D'Orb.*	—	×	
Cypricardia	—	—	×
Inoceramus	—	—	×
Lima spinosa, *Sby.*	×		
„ *sp.*	—	—	×
Rhynchonella Cuvieri, *D'Orb.*	×	×	
„ limbata, *Schlot.*	—	—	×
„ Mantelliana, *Sby.*	—	×	
„ plicatilis, *Sby.*	—	×	×
? Terebratula carnea, *Sby.*	—	—	×
„ semiglobosa, *Sby.*	×	×	×
Ananchytes ovata, *Leske*	—	—	×
Cidaris, spine	×		
Holaster planus, *Mant.*	×		
Micraster cor-anguinum, *Leske*	× ?	× ?	×
Ventriculites mammillaris, *Smith*	—	×	
„ radiatus, *Mant.*	—	×	

Upper Chalk.

A very large part of our area is occupied by the Upper Chalk, although it is to a great extent hidden by the Drift deposits. Beneath these it occurs over the tract of country between the outcrop of the Chalk-rock and the boundary of the Lower London Tertiaries, and it may be seen in many sections where the overlying strata have been denuded. It is more homogeneous than the Lower Chalk, and, even if sections were sufficiently plentiful, it is doubtful whether in a limited area it could be as easily divided into palæontological zones; certainly they would be neither as numerous nor as definite as those of the lower division.

The Upper Chalk is about 450 feet thick, judging from its outcrop and inclination, but only 268½ feet (the depth below the top of the division of a hard bed, 9½ feet thick) if it be the Chalk-rock met with in boring a well at Epping. It contains many layers of flint-nodules, and occasionally bands of tabular flint, which latter often fill the vertical and diagonal joints also, and sometimes cut across the bedding and through layers of nodules in a most irregular manner. The flint-nodules are black, with a white coating, the tabular flint is of the same colour, with its upper and under surfaces white also; occasionally, as at Sudbury, it presents alternations of black flint and white partings, each in thin layers less than a quarter of an inch thick, the white substance being almost as hard as the black.

The first three of the following sections are at about the horizon of the Chalk-rock; but there is no stratigraphical evidence to show whether that bed is above or below them.

In the chalk-pit N. of Tharfield there are few flints, but several small pipes of gravel run down into the Chalk. The pit half a mile N.E. of the same village is also in Chalk with few flints, and in some of the gravel-pipes the flints are green-coated (derived from the base of the Eocene beds). In the pit N. of Great Chishall Church the lines of bedding dip apparently 25° N. by W., this being on the line of flexure already noticed.

The pit N. of Little Chishall Church shows the thin edge of the Boulder-clay, with a hardened crystalline band of limestone at the bottom, over chalk, with layers of flint, tabular and in nodules, every 4 feet. About horizontal, and 16 feet shown.

FOSSILS FROM THE UPPER CHALK.

—	Pit just N. of Tharfield.	Pit at Smyth's End, Barley.	Pit ⅓ mile S.S.E. of Wenden Lofts.	Pit 1½ miles S.E. of Great Chesterford.	Lime-kiln ⅓ mile N. of Saffron Walden.	Pit E. of Newport Station.
Saurocephalus lanciformis, *Harlan* - -	—	×				
Dianchora striata, *Sby.* -	—	×				
Inoceramus Cuvieri, *Sby.*	—	—	—	—	×	
„ *sp.* - -	×	×	—	—	—	×
Lima Hoperi, *Sby.* -	—	—	—	×		
„ spinosa, *Sby.* -	—	—	—	×		
Ostrea - - -	—	—	—	—	—	×
Rhynchonella Cuvieri ?, *D'Orb.* - -	×					
Rhynchonella plicatilis ?, *Sby.* - - -	×					
Terebratula semiglobosa, *Sby.* - - -	×					
Scalpellum - -	×					
Ananchytes ovata, *Leske*	×	—	—	—	×	
Cidaris sceptrifera, *Mant.*	—	—	×			
„ serrifera, *Forbes*	—	—	×	—	×	
Goniaster, marginal plate - - -	—	×				
Micraster cor-anguinum, *Leske* - -	—	—	×	×	×	
Micraster cor-anguinum, var. gibbus - -	—	—	—	—	×	
Sponge, new, allied to Etheridgea - -	×					
Ventriculites impressus, *Smith* - -	—	—	—	—	—	×
Ventriculites quincuncialis, *Smith* - -	—	—	—	—	—	×
Ventriculites, *sp.* -	—	—	—	×		

At the pit half a mile S.S.E. of Wenden Lofts there is at the S. end a thin edge of the Boulder Clay, in a slight hollow, beneath this a thin bed of brown loam, and beneath this again the hardened crystalline band, 3 inches thick, which sometimes occurs at the base of the Boulder Clay. The white chalk has horizontal bands of flint-nodules; and a thin band of tabular flint runs diagonally across the bedding and through a nodular layer, at one point inclined thereto at an angle of 11°. At one part the tabular layer is wanting, but there are, just above the gap, several pieces of similar flint (in all about equal to the missing portion), arranged in a nearly vertical direction, the effect probably of some disturbance.*

The pit 1¼ miles W. of Littlebury shows 24 feet of chalk with flints, with, in some places, a thin band of yellowish chalky clay. About 15 feet from the top, there is a horizontal bed of fine yellow sand, chalky and very finely laminated, 2 feet thick, and about 10 yards in length. This is probably a branch from a large pipe.

The pit E. of Newport Station is in chalk with flints. A very persistent horizontal layer of tabular flint is in one part thrown down 18 inches by a fault, and two large pipes of gravel stop at this layer.

At Sudbury the uppermost beds of the Chalk are largely worked, underneath the Tertiary beds (*see* pp. 13–17): they contain few flints and comparatively few fossils.

LINE OF FLEXURE.

As a rule the Chalk lies very evenly, being either horizontal or dipping slightly to the S.E. But S. of Royston there is a very definite line of flexure which may be traced, by various pits above described, for a distance of ·5 miles along the line of escarpment, when the Chalk again assumes its level condition. This line of disturbance is a curve; it begins near the high road 2 miles S. of Royston, passing through the chalk-pits shown in Figs. 1 and 2, sweeps round Smyth's End, where the beds are again seen in the highly-inclined position (p. 7), and then runs N.E., by the pit just N. of Great Chishall (p. 10), which, however, is probably not quite on the line of greatest disturbance.

The flexure appears to have been very local, and of no great vertical extent. It occurs so near the top of the escarpment that all evidence of the lower part of the curve seems to have been obliterated by the denudation of the range. Still as there are no signs of Upper Chalk, but Chalk without flints occurs in all exposures at a lower level, it is probable that just below the level of the pits the beds begin to resume their horizontality.

W. H. P.

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* Like the broken and displaced flint-layer near Berkhampstead, described in *Geological Survey Memoirs*, vol. iv. p. 53.

CHAPTER 3.—LOWER LONDON TERTIARIES.

THANET BEDS.

During the progress of Geological Survey in 1873 the presence of Thanet Sand along part of the northern edge of the London Tertiary district, on the borders of Essex and Suffolk, was established. Before that the possibility of its occurrence in North Essex had been alluded to, but with doubt, by Prof. Prestwich.*

It consists of a fine compact sand, with a very slight admixture of clay; and at the bottom a more clayey bed, coloured green by glauconitic grains, and with green-coated flints derived apparently from the Chalk, by a process of slow dissolution of that rock;† and therefore its character here is the same as in Surrey, West Kent, and South Essex, and it is not like the more local fossiliferous beds of East Kent.

This division seems here to occur at the expense of the overlying Reading Beds, which are very thin, and there is most likely a continuous mass underground from this outcrop to that in South Essex, &c., many deep wells in the tract between seeming to pass through Thanet Sand (*see* Appendix 1).

Both the Thanet Sand and the Reading Beds are here so thin and so hidden by Drift that they could hardly be everywhere separated on the "one-inch" map, and consequently the former has been included with the latter. It is first seen a little eastward of Gestingthorpe, whence the boundary-line, winding along the right flank of the valley towards Sudbury, is for the most part hidden by the Glacial Drift that covers nearly the whole district. From Balingdon it can, however, be clearly traced along the right bank of the Stour to below Middleton, when it is lost under the gravel and marshland.

On the other side of the Stour the boundary is somewhat vague, being hidden by the gravel-flat, south of Great Cornard, when it is fairly traceable along the flank of the valley past Sudbury, though partly hidden under Drift, until beyond St. Bartholomew's it is wholly masked by the Boulder Clay. Beyond this it is not to be seen for some miles (in Sheet 48, N.W.).

It is possible that the green clayey bed at the base of the Eocene Series northwards of Bishop's Stortford may belong to this division of the Lower London Tertiaries rather than to the Reading Beds; but as this is uncertain it will be more convenient to describe it under the last head. Eastwards however of our district, near Ipswich, the similar bed does belong to the Thanet Sand, with little doubt.

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* *Quart. Journ. Geol. Soc.*, vol. viii. p. 241 (1852). *Ibid.*, vol. x. p. 92 (1854).

† For a fuller account of this peculiar bed see *Geological Survey Memoirs*, vol. iv. pp. 55–60.

The first sign of this division that I saw, beginning at the west, was about half a mile north-eastward of Gestingthorpe Church near the bottom of the lane to Hill Farm, where a little of the pink sand universally found at the bottom of the grey and buff sand in the neighbourhood of Sudbury was shown over the clayey green sand of the base-bed, at one spot only, there being Drift elsewhere along the lane.

At the cottage on the road to Bulmer a little north of this the sand was found (*see* p. 23).

At the old chalk-pit, marked on the Ordnance Map, three quarters of a mile west of Bulmer Church, the general order of the beds is as follows :—

Glacial Drift	Boulder Clay, mostly pale, but in parts darker, some feet.
	Chalk-rubble, with a layer of the dark-green sand from the "base bed" near the bottom, from 0 to 2 feet.
	Brown loam with stones (replacing the above).
Thanet Beds	Fine pinkish loam (sometimes resorted and with stones), from 0 to 3 feet (at the western end only).
	Base-bed. Dark-green sand, with brownish lumps; a few green-coated flints at the bottom in parts, from 0 to 1½ feet, resting fairly evenly on the Chalk.

Chalk with a few flints; a tabular layer of flint, mostly thin, within 2 inches of the foot.

At the northern part of the pit there is only a little Boulder Clay over the Chalk; the southern and highest part is mostly hidden by talus. At no part perhaps are all the beds to be seen together.

On the lane from Balingdon to Bulmer Church, and just out of the former village, there is a cutting on the southern side which, though overgrown, shows the sand, capped in parts by a little of the Reading Beds and with Chalk below, the junction being irregular.

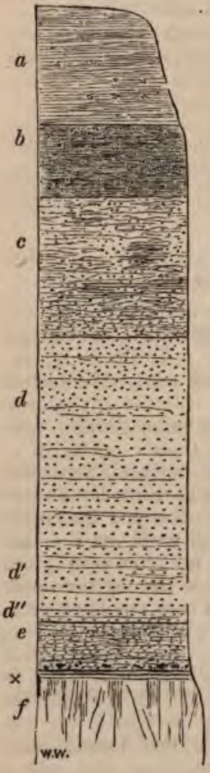
The windmill just west of Balingdon is on a small outlier, barely separated from the main mass, and forming a slight mound. The fine compact Thanet Sand may be seen on the road close to the mill, with Chalk lower down on the east, whilst at the top there seems to be a little sharp Drift sand (on the road west of the mill). At the hedge immediately beneath the mill (between it and the road), I saw the reddish bottom part of the sand, underlain by the upper dark green part of the base-bed (about a foot thick), and then the lower part, partly pale green or yellowish, but mostly ferruginous, especially at the bottom, and this I dug to a depth of over 3 feet before touching Chalk, the junction with which must be wavy. The old chalk-pit southwards of the mill seems to continue eastward to the brickyard, but it is overgrown. At the mill the upper part of the pit is in Thanet Sand and the lower in Chalk, but the junction could not be seen. Towards the road above mentioned there is, over the fine Thanet Sand, a little coarse gravelly sand, ferruginous, and with a good many flint-pebbles at the bottom part, which is suggestive of Crag.

The old chalk-pit marked on the Ordnance Map on the eastern side of the high road just S.W. of Balingdon was mostly overgrown when I saw it, but the following beds were to be seen:—a little very coarse gravelly sand, ferruginous and pebbly at the bottom (? Crag) over some 5 feet of Reading Beds, over Thanet Sand, over Chalk, all being even and flat. My notes of this section are incorporated in the account of the next, which is close by, at the very large pit south of Balingdon, on the road to Middleton, where the perfect succession from the London Clay to the Chalk is shown, the general section being as in Fig. 3, p. 14, but the highest beds occur only at the eastern and disused part.

Close to the above, divided from it indeed only by the road to Middleton, and connected with it by a canal-tunnel, is another large old chalk-pit. It is overgrown, and for the most part turned into a shrubbery and wilderness, but Thanet Sand is to be seen at the top, and at the highest part, close to the road, a small pit was open in this, with indications of the Reading Beds. This old pit joins on to that supplying the large brickyard on the east ("The Grove"), where a little of the pink sand and of the green base-bed are cut into in parts, over Chalk, though nearly the whole section is in various beds of Drift (*see* pp. 57, 70).

Fig. 3.—*General Section of the Great Pit S. of Balingdon* (*Sudbury*). 1873.[*]

Scale 8 feet to an inch.



		FEET.
	a. Brown and dark grey stiff London Clay, with race, slipping much; a few feet. I could see no sign of basement-bed.	
Reading Beds.	*b*. Blackish sandy clay and clayey sand - - - -	3
	c. Pale greenish-grey red-mottled bedded sandy clay, the red mottling chiefly in the upper part; the bottom part (with green grains) fills wee tubular holes in the underlying bed - -	6
Thanet Beds.	*d*. Buff and pale grey, fine, soft, and slightly clayey sand, firm and bedded. The bottom 3 feet or so (*d′*) of a pinkish tinge, the lowest 6 inches (*d″*) of a deeper colour, and harder; a slight intermixture of this with the top of the next bed for 3 or 4 inches - about	12
	e. Clayey greensand,[†] very bright-coloured at top, with green-coated flints at the bottom (some large), and a few higher up - about	2
	f. Chalk, with a thin layer of tabular flint, ×, of alternate black and white layers, at top;[‡] other flints rare - - -	to water.

The beds are even and flat, or with a S.S.W. dip (up to 3°).

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[*] From *Quart. Journ. Geol. Soc.*, vol. xxx. p. 402. Kindly lent by the Council of the Geological Society.

[†] This bed was noticed by W. SMITH in his "Geological Map of Essex," (1820) as "Greensand, called Devil's Dung," which name is still used in the neighbourhood.

[‡] This layer was also noticed by W. SMITH in his "Geological Map of Suffolk" (1819) as follows :—"Chalk, covered with a Floor of Stratified Flint."

On the southern side of the lane a quarter of a mile N.N.E. of Middleton Church an old-overgrown pit shows a little gravel and loam, over a little of the reddish sand, over the green clayey sand, over Chalk; the pit has reached further westward (or there has been another close by), and in the ditch at the junction of the roads, the junction of the Chalk and the Thanet Beds is shown. In another overgrown pit about the same distance eastward of Middleton there is Thanet Sand at top.

On the left side of the Stour the Thanet Sand extends, chiefly under Drift however, a little way into the next sheet (48 N.W.), but as the few sections are near the margin it will be convenient to describe them here.

The railway-cutting a mile south-westward of Little Cornard must have given a fine section of Drift and older Tertiary beds; but it is now turfed over, and therefore hard to make out, especially as the beds seem to be very irregular. Just south of the bridge the order seems to be gravel over clay, over sand (with loam and clay), and the clay seems to thin out southwards, but it is hopeless to make out anything clearly. On the other side of the bridge Boulder Clay, with brown clay beneath go down to the bottom. On the eastern side at the highest part of the cutting the succession seems to be—

Glacial Drift { Gravel.
A little Boulder Clay.
Brown clay, with a little coarse sand at the bottom.
Fine light-coloured clayey (Thanet) Sand.

On the opposite side there is red-mottled clayey sand (Reading Beds) above this last, and these reach nearly to the top of the cutting. At the northern part I saw only the fine Thanet Sand, sometimes capped with red-mottled sandy clay.

Northwards to Great Cornard the beds are hidden under valley gravel.

East of Sudbury is a line of chalk-pit, beginning more than a quarter of a mile north of Great Cornard Church, and running thence north-eastward for nearly half a mile. It is now mostly abandoned, part being orchard, but at the southern part the beds could be seen, and towards the other end the chalk was worked in (1873). The perfect succession of beds is given below, but the whole of them are not present at one spot; the Boulder Clay often resting on the Thanet Sand, having cut through the beds above, and at the southern end lying on the Chalk; sometimes, too, there is none of it. There are signs of a slight easterly dip.

Glacial Drift. { Pale Boulder Clay, lying irregularly on the beds below.
Coarse brown ferruginous bedded sand, with layers of ironstone and a few gravelly layers.

Reading Beds.—Light-grey sand with layers of Clay; the bottom part greenish and clayey up to 6 feet.

Thanet Beds. { Buff and pale grey, fine, soft and partly clayey sand, the bottom 3 or 4 feet with a pale pinkish tinge, darker at the lowest 6 inches; bedded, compact, and weathering like a soft stone; with a few small nodules of decomposed iron-pyrites; nearly 15 feet.
Clayey greensand, brightest at top; a few green-coated flints, mostly small at the base (? some pebbles) and a few higher up; from 1½ to 2 feet.

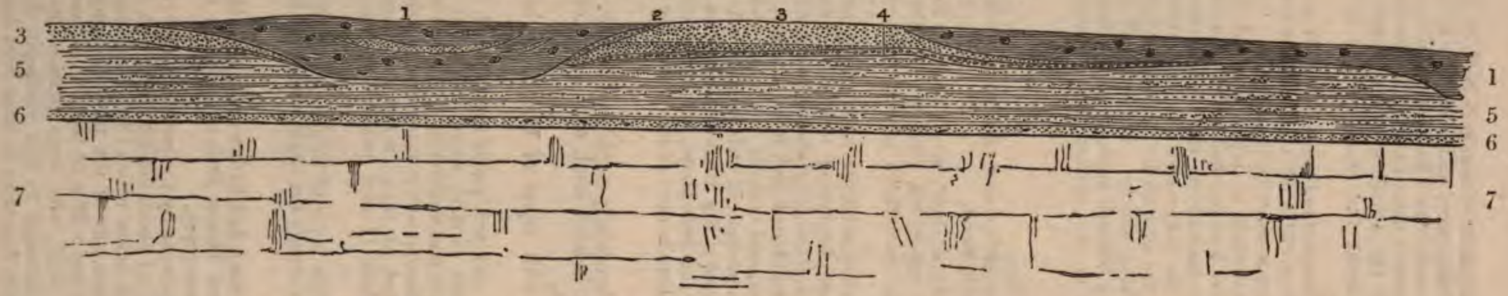
Chalk with a very few flints. A thin layer of tabular flint at the top. At parts this layer was seen to follow exactly the slight waving of the junction for some yards.

On the other (northern) side of the road, just before getting to the northern end of this section, a small pit showed Thanet Beds and Chalk; there being but little of the former, the junction was pipey.

On the southern side of the road passing by the cemetery, east of Sudbury, where the lane turns off to the old pit above noticed, there was a small pit showing Thanet Sand and its base-bed, below which Chalk had been got.

At the chalk-pit forming the northern part of the pits belonging to the old brickyard, a little westward, there is at top a little of the pinkish loam over the green base-bed, which is about 3 feet thick, with large green-coated flints, and rests evenly on the Chalk. At the entrance to this chalk-pit, however, the Thanet Beds sink suddenly and sharply, appearing to have been dragged down

Fig. 4.—Section in a Chalk Pit E. of Sudbury (1872).



Glacial Drift.	1. Pale Boulder Clay, in a hollow and cutting through the bed below, with a sandy base, and in part with lenticular patches of sand and darker clay at the bottom, up to 12 feet. 2. A thin patch of gravel at one part.
Red Crag.?	3. Brown ferruginous sand and yellow sand, dark at the bottom in parts, up to nearly 10 feet. 4. Gravel, chiefly of flint-pebbles and pieces of ironstone, with phosphatic nodules, from 0 to over a foot.
Thanet Beds.	5. Buff and pale grey, fine, soft, firm sand, the lowest part of a pinkish tinge which is deeper at the base, up to 12 feet or more. 6. Clayey greensand, brightest at top, with green-coated flints at the base, about 2 feet.

7. Chalk with a very few flints. At top a thin continuous layer (up to 3 inches) consisting of alternations of flint and chalk.

with a mass of Glacial Drift that comes on southwards, and to the description of which the reader is referred for details (*see* pp. 53, 55, and fig. 16.) The sand is also shown in the southern part of this series of pits, at the edge, by the footpath which divides it from the clearer section next to be described.

The chief face of the chalk-pit just out of Sudbury, on the northern side of the road to Great Cornard, shows an even and flat junction with the Chalk, and also a mass of Boulder Clay and sand, which latter may belong to the Red Crag, above the Thanet Sand. My colleague, Mr. Penning, has favoured me with the drawing of this section represented in Fig. 4. There were slight variations in the upper part of the section when I saw it on later occasions.

The sides of the pit slope towards the river, and along them there is a good deal of wash at the top which thickens lower down, and, towards the road, attains the dignity of a Valley Drift, consisting of stony loam with a little gravel at bottom in parts. At one part, on the western side of the pit, there is a hollow of the green sand divided by about half a foot of chalk from the tabular layer of flint.

On the road east of Sudbury, before getting to the cemetery, the Thanet Sand may be seen with Boulder Clay above.

The junction with the Chalk was clearly shown in the pit at the Victoria lime-kiln and in another pit close by, on the S.E. side of the road to Chilton Hall, just outside the town, and on the other side of the valley in the Alexandra Chalk-pit, and in some smaller pits a little nearer the town. Details of these will be given in the description of the Crag and the Drift (*see* pp. 31, 52–56).

The base-bed was again seen over the Chalk in a pit just southward of the waterworks, on the north of the town, but here also the Drift is the most notable thing in the section (*see* p. 52).

The chalk-pit just above the windmill and about a quarter of a mile W.N.W. of St. Bartholomews shows a few feet of loam and marl (not accessible) over the green base-bed, 2 feet thick, over the chalk. On the other side of the hedge (north) is a smaller pit than the last two.

W. W.

CHAPTER 4.—LOWER LONDON TERTIARIES—(*continued*).

READING BEDS.

This division of the Lower London Tertiaries consists, in our district, of mottled clay, sand, and loam, in varying proportions, and rarely reaching a total thickness of 40 feet. The component beds often pass into one another, and they are all unfossiliferous, except for the occasional occurrence of *Ostrea Bellovacina* in the green sand overlying the Chalk, which bed, however, may perhaps rather belong to the Thanet Sand (*see* p. 12).

The boundary runs irregularly from near the S.W. corner of the map, near Hertford, to near the N.E. corner, near Sudbury; but it is mostly hidden by Drift, and therefore uncertain. Where, however, there is an outcrop, a fairly marked feature is usually made.

A description of the Reading Beds in the Hertfordshire part of sheet 47 (from Hertford to Bishop's Stortford) has already appeared in the *Geological Survey Memoirs*,* and this description will be reproduced, with some revision, in the following pages.

Main Mass.

South of Hertford there is no outcrop to be seen, on account of the Boulder Clay that spreads up the gentle slopes of the hills. Thence to Amwell the Reading Beds are hidden by Glacial Gravel, those two deposits having almost the same boundary-line, near the top of the sharp slope that forms the right bank of the Lea. Southward to Hoddesdon the outcrop is somewhat vague, and then this series is hidden by the Valley Gravel.

The Reading Beds reappear on the other side of the Lea, above the Stort valley, and then the outcrop runs at first northwards along the flank of the valley of the Lea for about two miles, when it turns eastward, and runs with a generally N.N.E. course along the left side of the Ash for about 10 miles, the narrow outcrop being however much hidden by Drift.

The boundary-line then turns, and crossing the county-boundary (between Herts and Essex) for a short way, runs nearly south to Bishop's Stortford, the outcrop extending through, and a little south of, that town, and returning northwards along the other side of the Stort, and its tributary from Elsenham, the beds being however much hidden by Glacial Gravel.

From Elsenham eastwards the Reading Beds are hidden under the mass of Boulder Clay for many miles, and their boundary-line is therefore doubtful until they reappear on the east of Gestingthorpe, whence this line, partially hidden by Drift, closely follows that of the Thanet Beds along the flank of the hills and the valley of the Stour, again to be lost under Boulder Clay for many miles beyond Sudbury.

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* Vol. iv. "The Geology of the London Basin," Part I., pp. 227–232, 238 (1872).

At the kiln half a mile south-west of Rush Green, near Hertford, there is London Clay in an old overgrown pit close to and east of the house. The present pits are north-west of the house, and give the only good section in the neighbourhood, the beds being as in Fig. 5, p. 20.

An old chalk-pit in the small wood just north-west completes the section, and shows the following beds :—

Glacial Gravel, a few feet.	
Reading Beds.	Sand, with flint pebbles scattered at the bottom, where there are also oyster-shells here and there. Flint-bed, about a foot thick, many of the flints large : in parts with a thin blackened clayey layer at bottom : resting irregularly (with a waved junction) on
Chalk with flints.	

In the road-cutting about a quarter of a mile south-eastward from the Hertford Union a little sand and the flint-bed are shown between the gravel and the chalk, and in the chalk-pit just north the flint-bed is again to be seen in the same position. In a small pit in a hollow a little southward of the New River Head, the sand and the flints were found below gravel, and along the sharp slope just east of the house at Amwell Bury I saw here and there fine sand, most likely belonging to the Reading Beds, just over chalk, whilst above, the gravel comes on at once.

Whether the sand at Amwell is an outlier or not is hard to say, but if not quite must be almost so. The only section of it that I saw was in an old pit (marked on the Ordnance Map) on the western side of the high road and south-west of the church, in great part filled up, but showing the following beds :—

Gravel, 8 feet or more.	
Reading Beds, about 20 feet.	Light-coloured fine sand, mostly white or nearly so ; with a few thin clayey lines, showing the bedding, and in the lower part two lines of scattered flint-pebbles. Layer of flints, many large.
Chalk.	

In the hollow about half a mile north-east of Little Amwell Church the remains of a " chalk well " showed sand and clay of the Reading Beds, as also did a ditch a little to the east.

" In an old pit at the road-fork S.E. of Stanstead Abbots there is London Clay (2 or 3 feet) on grey sand."*

The following succession of beds was made out from a deep overgrown ditch down the hill about half a mile north-eastward from St. Margaret's Railway Station :—

Irregular wash of gravel.	
Reading Beds.	Mottled clays, mostly sandy ; some thickness. A little sand, and lower down— Sand, with a broken line of pebbles close to the bottom. Green-coated flints, 6 inches.
Chalk.	

The clayey Reading Beds throw out water from the gravel that caps the hill. A little N.N.W., at a small gravel-pit, the variously coloured and partly sandy clays again occur beneath the gravel ; and at an old pit just north (marked on

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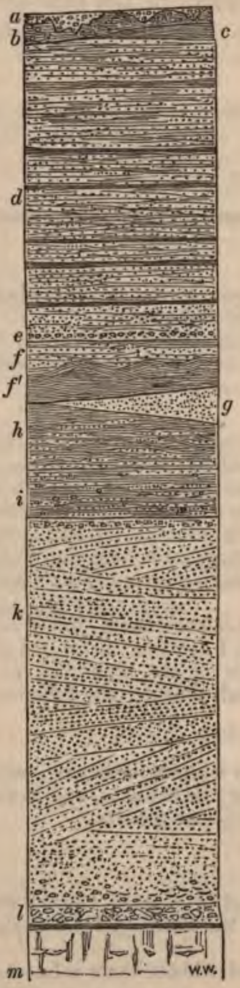
* From Mr. Penning's notes.

Fig. 5.—*General Section at Mr. Line's Brickyard, E.S.E. of Hertford* (1869).
Scale 8 feet to an inch.



		FEET.
	a. Small pipes of gravel in parts.	
	b. Thin wash of London Clay, with flints and pebbles, chiefly at the N.W. end.	
London Clay.	*c*. Dark brown clay; very little, and at the S.E. end only.	
	d. Basement-bed. Brown bedded sandy clay and (in lower part) clayey sand, with thin layers of clay. Green grains here and there, and small ferruginous concretions, in one of which I found an impression of a bivalve. At the bottom a layer of black flint-pebbles (*e*) - - about	12½
	[The above was a long section; its continuation downwards was from smaller pits just below.]	
Reading Beds, 25 feet or more.	*f*. Pale grey and brownish sand and clay, irregularly resting on, or passing down into, very pale greenish ochreous clay (*f'*) - - -	2 to 3
	g. Pale lilac firm fine sand thinning out at the N.W. -	0 to 1½
	h. Purple grey red and brown mottled clay, in part sandy; passing into the bed below -	2 to 3
	i. Pale grey sandy clay with some small flint-pebbles; passing into the bed below - nearly	2
	k. Light-grey sand streaked with brown, false-bedded; with an interrupted layer of small flint-pebbles close to the top	16 (or more)
	l. Flints (some large) and flint-pebbles in sand, touched at bottom.	
	m. Chalk.	

This section differs so much from that published by MR. PRESTWICH in 1854, as from the same place, or close by, that I have been led to suspect some accidental error in his account (? from misplacement of the section). The difference seems too great to be accounted for by variations in the beds, although there were differences in the various pits at the time of my visit. The older account is as follows*:—

		FEET.
Basement-bed of the London Clay, with casts of *Panopæa* -		6½
Reading Beds. 31 feet.	Light-greenish sand - - - - -	4
	White or ash-coloured sand - - - -	6
	Light-yellow sands - - - - -	4
	Light-coloured mottled red and grey clays - -	10?
	Yellow sand with *Ostrea Bellovacina* in places at its base	6?
	Green-coated flints - - - - -	1
Chalk.		

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* *Quart. Journ. Geol. Soc.*, vol. x. p. 92.

the Ordnance Map) then only clear in parts, the section was as follows (in 1869), the Reading Beds being however inaccessible:—

		FEET.
Gravel, in parts with a wash of loam, &c. - - about		6
Reading Beds.	Grey and red clay, seemingly sandy, and passing down into the bed below -	1 to 3
	Grey sand, stained brown at top - -	4 to 6 or more.
	Green-coated flints, resting unevenly on the Chalk.	
Chalk with flints.		

W. W.

In the road-cutting south of Widford Railway Station the following succession was seen, but no measurements could be taken:—

Glacial Drift.
- Grey Boulder Clay.
- Gravel.
- White Boulder Clay.
- Gravel.

Reading Beds. Fine light-green sand, from a foot to 3 feet thick, the lower part clayey, with green-coated flints.

Chalk.

In a section along the western side of the road east of Hadham Mill, Boulder Clay, Gravel, and Reading Beds are cut through to the Chalk.

A pit a quarter of a mile east of Hadham Mill gave the following section, the Reading Beds being cut off towards the valley (westward), so that the gravel then rests on the Chalk:—

Gravel and Sand (Glacial Drift) chalky at the bottom, ? 20 to 30 feet.

Reading Beds.
- Light-brown clay, with race, a foot.
- Light-green fine sand, the bottom part somewhat clayey, and with green-coated flints, 3 feet.

Chalk.

Just east of Hadham Ford another pit showed a like section. [This was cut further back at the time of a visit, with Mr. Penning, in 1873, from a note of which I have made some addition to the former account, in Vol. IV., p. 229.—W. W.]

Glacial Drift, gravel, and sand, 8 feet.

Reading Beds.
- Fine white sharp sand, a few inches.
- Mauve-grey sand, 12 to 18 inches.
- Layer of flint-pebbles.
- Pale greenish fine soft sand; here and there a pebble, and at the bottom green-coated flints and pebbles, 8 or 9 feet.

Chalk, with horizontal layers of flint about 8 feet apart.

At the neighbouring brickyard white sand occurs beneath the basement-bed of the London Clay (*see* p. 28).

In an old pit by the road leading to a farm half a mile north-east of Little Hadham, sand and pebbles occur on Chalk, but the section is overgrown.

Mr. Prestwich has noted the following section (now hidden) at Patmore Heath.* :—

	FEET.
Brown clay and gravel - - - - -	1
Mottled red-brown and grey sandy clay - - -	2
Ash-coloured sand, with seams of brown clay and a seam of flint-pebbles - - - - - -	2½
Flint-pebbles in light greenish-grey clay - - -	1½
The Chalk crops out about 6 feet lower.	

In a pit at the south-western corner of the wood, a quarter of a mile east of Patmore Heath, loam and pebbles cap the chalk.

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* *Quart. Journ. Geol. Soc.*, vol. x. p. 92.

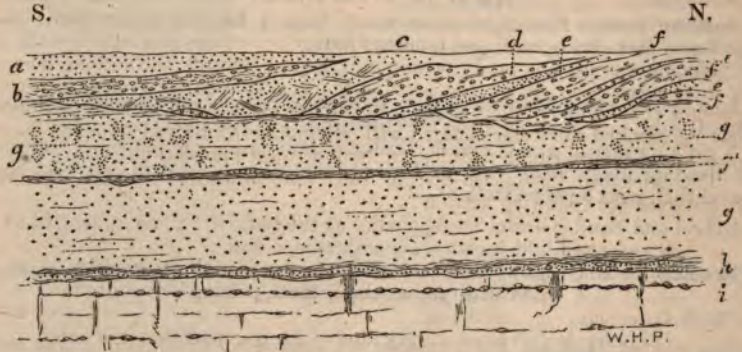
In another chalk-pit on the eastern side of the road, half a mile north of the same place, there are traces of the Reading Beds at top, and they were seen in a ditch on the higher ground a few yards further back.

At Bishop's Stortford there are three brickyards near together in Rye Street. The following notes were taken in 1877, when the pits had been cut further back into the hill than was the case when the earlier notes of two of those pits were made.* The most northerly brickyard is Mr. Cornwell's, and this gave a good section for a length of more than 50 yards, a part of which is shown in Fig. 6, the beds *a* and *b* occurring only on the south, and the lowest bed being touched on the north.

In the description of this and the other two sections the same letters have been used for the same beds.

Fig. 6.—Section in Mr. Cornwell's Brickyard, Rye Street, Bishop's Stortford, 1877.

Scale 25 feet to an inch.



		FEET.
Reading Beds.	*a*. Very fine light-coloured evenly-bedded sand -	3
	b. Grey sandy loam, with a few flint-pebbles and many nodules of bright red ironstone in all stages of decomposition - - - - - -	2
	c. Fine light-coloured false-bedded sand; *d*. Pebble-bed, like *b*.; *e*. Fine sand; *f*. Pebble-beds. All these are false-bedded, at an angle of about 12°, and rest irregularly on the bed below: up to about	10
	g. Grey sandy loam, with a thin bed of clay *g'*, about the middle, above which it is mottled with deep red patches: clayey at bottom - - - - -	17
	h. Brown clay, with green-coated flints and pebbles	1

i. Chalk with flints, the top few inches stained yellow (*Belemnitella mucronata*.)

The pit in Mr. H. Glasscock's brickyard, just south, gave the following section:—

Brown London Clay, 5 feet.

Reading Beds.	*a*. to *f*. represented by mauve sand (the same as in Mr. Dickenson's brickyard), in one place only, up to 2 feet.
	g. Grey sandy loam as before, the upper part mottled; not bottomed.

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* *Geological Survey Memoirs*, vol. iv. pp. 230, 231 (1872).

The pit in Mr. Dickenson's brickyard, just south of the last, showed—

		FEET.
Brown London Clay		10
Reading Beds.	*a.* to *f.* are represented by a bed of very fine light-mauve sand, (lenticular patch)	0 to 3
	g. Grey sandy loam, with a thin bed of clay about the middle, above which it is mottled with deep red patches. (Impressions of shells are said to occur in this)	15
	h'. Brown clay	4
	h. „ „ with green-coated flints and pebbles	1 to 1½
Chalk with flints.		

In these three sections the surface of the grey mottled loam is very irregular, having been probably denuded by the currents to which the false-bedding of the overlying sands and pebble-beds is due.

In the southern pit the London Clay rests directly on the mottled loam (except where the lenticular patch of mauve sand intervenes), and the sands and pebble-beds above the loam in the northern pit are most likely the remaining portion of a narrow ridge which does not extend far in any direction. They probably thin out beneath the London Clay, which comes on just above the pit.

The mass of loam is sandy throughout, except towards the bottom, where it is more clayey, and in all the sections it has a thin band of clay, with small patches of sand about the middle. Below this there is no mottled staining, it having checked the water charged with salts of iron (derived from the decomposition of the ironstone nodules) in its downward percolation.

The brickyard just south-east of the Nonconformist School, at the same town, gave the following section:

		FEET.
Soil and wash		2
London Clay, brown and tenacious, passing into the bed below		2
[? Basement-bed of London Clay.—W.W.]	Whitish rather clayey sand, passing down into the next bed	3
	Whitish clayey sand. At one part near the base 2 inches of very dark sand, with race and an occasional flint-pebble	9
Reading Beds	Green finely bedded sand	2
	Whitish clayey sand	7
	Brown clayey sand	2
	Dark green clayey sand	4
	Hidden by slips, &c.	3?
Chalk.		

The sands are generally laminated, some very finely, and all the beds pass into one another without any definite line of separation.

In a pit at the corner of the wood at the north-eastern end of Stansted Park, about half a mile east of the castle, the following beds are shown :—

Reading Beds	Mottled greenish and yellowish clayey sand, 8 feet.
	Pebbles in brownish clay, 9 inches.
Chalk with flints.	

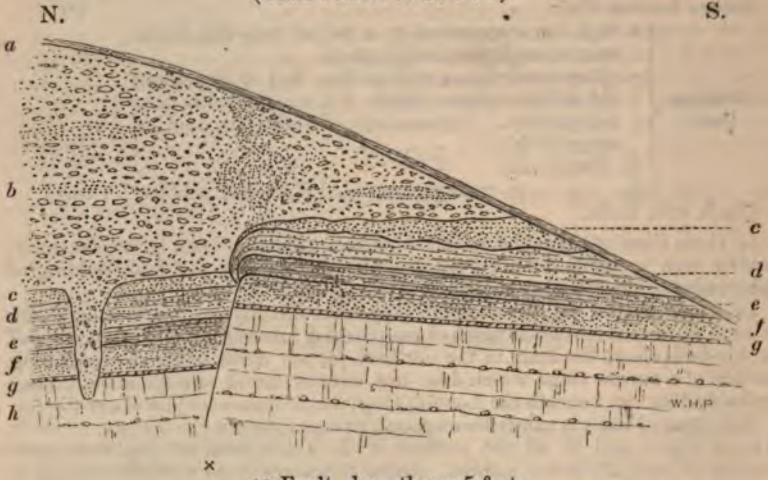
A pit at the "Castle," Stansted Montfitchet, gave a good section, with a small fault, as in Fig. 7, p. 24. W. H. P.

From Elsenham we have seen nothing of the Reading Beds for a distance of nearly 18 miles, when they again appear at Gestingthorpe. Here I found a little green sand [? bottom-bed] underneath the Drift in the small valley N.W. of the church, and at the brickyard the top of the series is touched in one of the pits (*see* p. 28).

In the garden and old pit at the cottage on the road to Bulmer, about two thirds of a mile N.E. of Gestingthorpe Church, the following section was got, chiefly by digging, as the shallow pit is overgrown :—

Reading Beds.	Light-coloured sand, at the highest part.
	Pale green clayey sand, slightly mottled red.
	Light-coloured and pale green sand with a layer of clay, greenish at the bottom.
Fine buff and grey Thanet Sand.	

Fig. 7.—Section in a Pit at "Old Castle," Stansted Montfitchet.
(Scale 16 feet to an inch.)



× Fault, downthrow 5 feet.

		FEET.
	a. Soil.	
	b. Gravel and sand (Glacial Drift) - - - -	up to 20
Reading Beds	*c.* Green sand mottled red - - -	$\frac{1}{2}$ to 4
	d. Green loamy sand - - -	2 to 3
	e. Dark sandy loam with occasional pebbles and a thin white clay-layer - -	$1\frac{1}{2}$
	f. Green sand, slightly mottled yellow -	2 to 3
	g. Thin layer of green-coated flints.	
	h. Chalk with layers of flints at regular intervals.	

The London Clay is touched in a ditch on the south, and a little higher.

Beyond this nothing is to be seen for some way, except for some indistinct signs in the valley S.W. of Bulmer.

There are signs of the Reading Beds along the lane nearly a mile eastward of Bulmer, and they are shown, above the Thanet Sand, in the sections at Balingdon, (pp. 13, 14), where their thickness is very small.

In the fields on the slope of the valley about a quarter of a mile south-eastwards of Middleton greenish red-mottled sandy clay (like that in the Balingdon section) is ploughed up in places, whilst higher up there is a brown loamy soil with flint-pebbles (the basement-bed of the London Clay).

At the north-eastern corner of the small wood half a mile south-east of Middleton there is again a little of this clay, whilst in the field just west the ground shows unmistakable signs of the outcrop of a sandy pebble-bed, which seems to have been dug for gravel, as there is a trace of a pit just below where the London Clay comes on. Close by, at the western edge of the wood, there is some sand, which must come between the pebbles and the mottled clay. I know of no other sign in this neighbourhood of such a bed as this mass of flint-pebbles, which must be a very local patch, rising up in a hillock, and may represent the Oldhaven Beds, the comparatively local series between the London Clay and the Reading Beds, in which case this is the first record of their occurrence along the northern edge of the London Basin, the local outcrop at Ipswich not having been described.

Southwards the Reading Beds are hidden under the Valley Gravel; but they reappear a little way up the short tributary valley from Great Henny, on the northern side of which green and red mottled sandy clay (the same as that of the Balingdon section) was seen in two field-ditches on either side of the lane that crosses the valley westward of the high road, whilst on the high road itself the same occurs immediately bordering the stream, with the higher bed of black clay above.

On the other side of the Stour the Reading Beds are touched in the railway-cutting south-westward of Little Cornard and at one part of the large pit north of Great Cornard Church (*see* p. 15).

The only sign of the Reading Beds from Sudbury northwards is in the lane about a quarter of a mile north of St. Bartholomew's, where a little greenish red-mottled clay and sandy clay may be seen: a small spot bare of Drift, which hides everything on the east for a long way.

Outliers.

In the western part of the district there are a few outlying masses of the Reading Beds, wholly cut off from the main mass, that show the former extension of the beds over the Chalk, from off which they have been removed by denudation to a very great extent. It may be noticed that four of these outliers are roughly in line, from W.S.W. to E.N.E., the spur of the main mass N.N.W. of Bishop's Stortford being also in the same alignment.*

Sacomb.—This outlier is much hidden by Boulder Clay, which makes the boundary doubtful. "The road nearly half a mile east of Sacomb Pound gives a section of about six feet of mottled clay and sand, with two lines of pebbles; higher up, where the rise is sharp, London Clay may come on, but if so it is concealed by the Boulder Clay over the high ground."† At the bottom of the Reading Beds there are green-coated flints.

Collier's End.—The larger outlier here, also mapped by Mr. Bennett, is in like manner covered by Boulder Clay; but there is one good section, which I saw in good order; it is given by the pit at the kiln, on the northern slope of the side-valley just south of the village and east of the high road, which showed the following beds in 1869:—

		Feet.
Reading Beds, about 21 feet.	Brown clay with race, especially in one layer - - - - -	8
	Black clay - - - - -	about 3
	Light-coloured clay and red mottled clayey sand, with flint-pebbles (3 inches) at bottom - - - - -	„ 2
	Light-grey bedded sandy clay, red-mottled, except in the lower part, which is more sandy - - - - -	over 7
	Very small flint-pebbles and green-coated flints in greenish clayey sand (bottom-bed) resting evenly on the Chalk -	about ¾
Chalk with flints.		

This section is most likely clearer than when seen by Mr. Prestwich, who speaks of the mottled clay resting directly on the Chalk,‡ perhaps from a slip?

W. W.

Braughing.—Between this village and Hadham Ford there is a large outlier, in great part with a doubtful boundary, being much covered by Glacial Drift. Three sections showing the junction with the Chalk were noted, the layer of green-coated flints being present in each next above that rock: in one, three quarters of a mile N.E. of Stondon, 3 feet of flint-pebbles were seen; in another, a quarter of a mile S.W. of Warren's Farm (S.E. of Braughing), 4 feet of mottled loam; and in the other, just south, a foot of pebble-gravel over 5 feet of mottled loam.

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* See *Geological Survey Memoirs*, vol. iv. pp. 351, 252, for a notice of such lines of outliers, &c.

† From Mr. F. J. Bennett's Notes.

‡ *Quart. Journ. Geol. Soc.*, vol. x. p. 92 (1854).

South-west of Manewden (in Essex) is another outlier, also partly hidden by Drift, but the junction with the Chalk is shown in a pit a quarter of a mile south-east of Mallows Green, the section being:—

Bottom-bed. Dark green clayey sand, with small patches (4 or 5 inches thick) of pebbles on the top, and a thin layer of green-coated flints in brownish clay at the bottom; 2 to 3 feet.
Chalk, surface irregular.

On the hill W.S.W. of Stansted Station is a smaller patch almost wholly hidden by Drift, but in the large pit, marked on the Ordnance Map, south-east of Bendfield Mill, the following section may be seen:—

		FEET.
Glacial Drift	Patch of gravel.	
	Grey boulder clay	up to 8
	Trace of pale grey sand with pebbles.	
Reading Beds	Greenish sandy clay, brown in the middle, and light-coloured at bottom [This is much like the base-bed of the Thanet series.—W. W.]	7
	Green-coated flints and pebbles	½
Chalk with flints; one very regular flint-layer, 4 inches thick, 2 feet from the top		40

At the northern edge of the district, and miles from any mass of the Reading Beds, there is a remnant in a chalk-pit by the road about two-thirds of a mile S.S.E. of Kedington Church, on the border of Suffolk, where the following section occurred:—

Boulder Clay, with a thin layer of reconstructed chalk at the bottom.
Reading Beds. Fine greenish sand with flint-pebbles and flints. A thin layer on an irregular surface of the Chalk.
Chalk with few flints.

W. H. P.

CHAPTER 5.—LONDON CLAY AND RED CRAG.

LONDON CLAY.

This deposit is for the most part of a uniform character, consisting of clay, bluish-grey where not exposed, but changing to brown at the surface, and sometimes with nodular masses of cement-stone (septaria). There are more sandy beds occasionally, especially at the top (which does not occur in our district) and at the bottom. The base indeed is marked by the occurrence of the peculiar and generally easily recognized "basement-bed," a loam or clayey sand, mostly with green grains and layers of flint-pebbles, often with fossils, and sometimes with hardened calcareous masses.

Speaking of the S.E. corner of our district, Mr. Dalton remarks that "in some parts friable nodules of carbonate of lime occur near the surface of the clay, whilst in other parts chalk or lime is required to neutralize the sulphuric acid, whether free or combined with iron, which is formed in the clay by the oxidation of pyrites. In the presence of pyrites and carbonate of lime crystals of selenite, and carbonate of iron soluble in water containing carbonic acid, are formed, the last speedily changing to peroxide, with the evolution of carbonic acid."

Although it occurs over the S.E. half of the tract represented in Sheet 47, yet the London Clay crops out over no large area, owing to the very general covering of Drift. Its boundary-line, which is for the most part doubtful, from this Drift-covering, follows that of the Reading Beds at varying distances, from a tenth of a mile to three miles.

After passing under the Drift near Bishop's Stortford the boundary is hidden until it reappears W.S.W. of Sudbury; but the formation has been exposed by the cutting-out of the deeper valleys, the sections along which will be noted in order, from west to east, and from the head downwards, after describing the northern outcrop.

There is a good section of the junction with the Reading Beds near Hertford (*see* p. 20).

At the brickyard on the left bank of the Stort, about half a mile below Roydon Station, I saw the section below, in company with Mr. Penning, in 1873:—

		FEET.
London Clay.	Brown and grey bedded clay, with some sharp casts of radiating crystals of selenite: fairly divided from the bed below	15 or more
	Basement-bed. Brown loam with a few shells and some lumps of stone (with a few shells and pieces of plants); 6 feet shown, but said to be 7 feet deeper	about 13
Reading Beds.	Greenish mottled clay and puce clay	„ 2

W. W.

At the brickyard east of Hadham Ford there is a good section of the basement-bed, the following account of which was taken in 1869 [with an additional note in 1873, when the pit was deeper.—W. W.]

		FEET.
[London Clay].	Brown clay, rather sandy, especially towards the bottom; with patches of small darker lumps of tenacious clay, some pieces of septaria and lumps of race, impressions of shells and an occasional small pebble or piece of ironstone. Near the bottom two or three thin layers of dark clay	14
	Yellowish finely-bedded sand	1
	„ „ „ full of shells, too friable for preservation, with some pebbles: in places a thin layer of clay between the two beds of sand	1
[? Reading Beds].	Very fine white sand, finely bedded, with some dark grains, and here and there small lumps of dark clay	about 8
	Pebbles.	

To the "basement-bed" probably belongs the greater part of the top bed as well as the next two beds.

South-east of Hadham Park there is a brickyard in brown sandy London Clay.

About a mile and a quarter N.E. of Bishop's Stortford, at the edge of Birchanger Wood, the London Clay is worked in a brickyard. W. H. P.

At the higher kiln, Gestingthorpe, about a third of a mile S.S.E. of the church, a fine section of the bottom part of the London Clay is laid open, and shows a thick development of the sandy basement-bed, which at Sudbury, a few miles eastward, seems to be absent. The details were as follows, the bed below the pebbles being shown only in a small pit at a lower level than the chief one, and those beneath that not being open at the time of my visit, (1873):—

A little pale Boulder Clay at the eastern part.

			FEET.
London Clay.		Brown and grey mottled clay, passing down into the next	about 6
		Brown sandy clay, with an even bottom	up to 3½
	Basement-bed.	Very pale buff fine sand (like that of the Oldhaven Beds); a long lenticular mass at one part cutting down suddenly into the bed beneath to a depth of over 2½ feet; at one part a layer of brown clay at top and another at bottom, which join together where the sand thins out	0 to about 3
		Brown loam, with a few layers of clay throughout; the lower part more clayey and passing down into the next	over 12
		Darker brown and grey clay, passing down into the next	about 2
		Brown loam, like that above	1 or more
		Sandy pebble-bed; the pebbles mostly small, but some large. The lower half sand with pebbles, Teeth of *Lamna* were found in this bed by Prof. Prestwich	about 2
Reading Beds.		Buff sand, the upper part fine soft and with a little clay, the rest sharper	said to be 6
		Clay (not seen, information from workmen)	6 or 8
		White sand „ „ „ „ „	

The cut surface of the loamy basement-bed stands almost vertically; the thicknesses given are maxima.

The pebble-bed and the loam above were also seen on the opposite side of the valley, eastward, close to the bottom, where there may be a small inlier of the Reading Beds, as the loam occurs further down northwards, pointing to a slight uprise southwards.

At Wisboro Hill, a mile and a quarter S.W. of Bulmer, is a pit to supply the brickyard, by the high road on the south, which showed (1873):—Drift sand at the highest part, over brown grey-mottled bedded and more or less sandy London Clay; and at the north of the kiln there is a sandy wash, gravelly at the bottom, over like London Clay.

The London Clay is again shown at one part of the large pit at Balingdon (p. 14.)

W. W.

Chelmer Valley.

The London Clay is shown at the brickyard a quarter of a mile N.W. of Thaxted (*see* p. 42).

In a deep water-course half a mile S.S.E. of Thaxted Church the following section occurs:—

		Feet.
Glacial Drift.	Coarse yellow sand and fine gravel, bedded and with iron-shot streaks. The lower part Red Crag, or rearranged Red Crag, containing phosphatic nodules	8
London Clay (basement-bed.)	Light-coloured loamy sand	1
	Hard brown sand, concretionary	½
	Light-brown sandy clay, streaky and slightly contorted, with calcareous concretions and patches of tenacious clay, passing down into the bed below	2 to 3
	Dark fine loamy sand, somewhat muddy, with very fragile shells	5

In a similar gully 2 miles S. of Thaxted may be seen similar dark fine muddy-looking sand, and a brick-pit half a mile N.N.E. of Little Easton Church is in sandy loam over London Clay, 3 feet.

W. H. P.

Ter Valley.

The London Clay was shown (1872) in recently-dug ponds at Maddox Farm, about a mile below Terling, and it may be seen further south, on the left bank, along the high road.

Guith Valley.

In the railway-cutting south of Bulford Station the Clay seems to be impregnated with sulphate of iron or free sulphuric acid, as during the construction of the line the hair was taken off the legs of the horses employed.

London Clay has been dug, to a small extent, in the bottom of the valley at the brickyard a quarter of a mile S.S.E. of Faulkbourn Hall.

Blackwater Valley.

A brickyard was worked (1872) in the London Clay near Bay Tree Farm, on the high road south of Stisted.

It has been worked at the kiln northward of Coggeshall, and it was shown in the brickyard north-west of that town (*see* p. 62).

The clay may be seen on the northern bank of the artificial lake in Braxted Park, and, on higher ground, at an old brickyard a quarter of a mile north of Bung Row.

It forms the floor of the railway-cutting at Wickham Bishop, from the station to halfway between the bridges, the gravel being cut through.

Septaria occur close to the surface in the wood a mile S.W. by S. of Wickham Station.

Tiptree Heath.

The great brickyard half a mile west of Primrose Hill shows, at one part, several feet of the clay, which there contains soft friable calcareous nodules, apparently segregated by the action of the weather.

At Chiseldine Grange I was told that masses of apparently the same nature, and of the size of a man's head, occur at intervals in the clay to the depth of 30 feet, which is about the depth to which the discoloration of weathering generally extends.

W. H. D.

Colne Valley.

At the brickyard nearly a mile westward of Castle Hedingham the following section was noted:—

Coarse ferruginous sand with nodules and thin beds of ironstone here and there, and some flints and pebbles [? Crag or Drift], 7 feet.

Basement-bed of the London Clay. Brown sandy loam, with layers of clay, and a layer of fine white sand, 6 feet.

A better section was shown at the kiln on the other side of the railway, about three quarters of a mile south of the same village, and close to the railway, the beds being:—

		FEET.
Glacial Drift.	Boulder Clay A little gravel	1 to 6
Basement-bed of London Clay.	Brown sandy clay	4 to 6
	Fine buff sand, with a layer of clay at top and at bottom	3 to 4
	Brown sandy clay, not bottomed.	

The basement-bed is also shown in the railway-cutting, close by to the west, but the section is not clear and is difficult to make out, from the way in which the Drift (Boulder Clay and sand to a thickness of 20 feet) cuts into the other beds.

At the Wash, in the side-valley eastward of Halstead, stiff chocolate-coloured clay is dug for the supply of the kiln.

F. J. B.

Outliers.

The only outliers of the London Clay known in our district are on those of the Reading Beds. At Sacomb (p. 25) there is no good section; but at Colliers End (p. 25), though great part of the outlier is hidden by Drift, a fair section was seen in a pit on the western side of the high road, opposite the kiln, which showed the following beds:—

Brown finely-bedded sandy clay and loam, nearly 10 feet.

Brown clayey sand (basement-bed), 4 feet (to water).

At the S.W. of Benfield End the brown loam of the basement-bed was seen, in cutting a drain, but it cannot extend far.

RED CRAG.

There is no trace of the Bagshot Beds in our district, and until the Geological Survey of it was almost finished the London Clay was thought to be here succeeded by the Drift; but in 1873 unmistakable remains of the Red Crag, with the phosphate-bed at the base, were found at Sudbury, round which town there has been of late years a great development of pits, for chalk, brick-earth, &c. A notice of this discovery, but without details of the sections, was communicated to the Geological Society.*

The most westerly traces of the Crag noticed were on the south of Thaxted, where Mr. Penning and myself found in the water-course, noted at p. 29, some small phosphatic nodules and a piece of phosphatized bone in a thin layer of gravel at the bottom of sand, and lying on London Clay; besides some larger phosphatic nodules on the surface further south, at the junction of the sand and clay.

I also found a like piece of phosphatized bone in the flint-bed at the base of the sand, and resting on the Chalk, near Stoke

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* See *Quart. Journ. Geol. Soc.*, vol. xxx. p. 401 (1874).

(*see* p. 49). A mass of shells was said to have been found at one spot just above this flint-bed, and some of these that were shown to us were the common shell at Sudbury, *Purpura lapillus*.

It is only at the north-eastern corner of our district that there is anything more than a mere trace of a former existence of the Crag, unless, as is not impossible, some of the sand that has been classed with the Drift should turn out to belong to the Crag. In the outskirts of Sudbury are the only patches that can be shown on the map, and these, moreover, are small, the Crag being mostly covered by Drift, underneath which its extension is doubtful.

Some of the sections where Crag occurs have been already described (pp. 13, 16, 17), and others will be noticed further on (pp. 52–56).

At the N.E. edge of Sudbury, by the side of a footpath running N.E. from near the top of Suffolk Road, two small chalk-pits (Webb's) gave the best sections of the Crag (1873–5). The further of these is close to the pit described on p. 52, where also Crag was touched, and showed the following beds :—

Boulder Clay, at one spot, cutting down to the greensand of the Thanet Beds.

Red Crag.	Ferruginous sand, slightly false-bedded; in parts a light-coloured grit, with broken shells, and with unbroken specimens of *Purpura lapillus* (var. *crispata*). With layers of ironstone, and at the bottom a firm bed of it. A line of pebbles &c. about 2 feet from the bottom. Up to 6 feet thick.
	Layer of flint-pebbles, phosphatic nodules, and flints, 3 to 12 inches.

Clayey greensand, with green-coated flints (base of Thanet Beds), 1½ to 2 feet.

Chalk.

The other pit, close by to the S.W., gave a like section, with a shallow trough of Boulder Clay on one side, and the Crag having less ironstone and less of the pebble-bed (sometimes hardly any).

Down the slope of the side-valley, just south-eastward of the above, and facing the road in that valley, another pit (Harding's) gave a like section of the same beds, without the Boulder Clay, in a slight hollow in the Chalk, the Crag consisting of ferruginous sand, up to 10 feet thick, with pebbles and nodules (one layer at the bottom and others above), and with sandy ironstone, one bed of which contained many casts and impressions of fossils.

The following is a list of the fossils from the Crag in these pits. As however the specimens were in the state of casts or impressions, except in the cases marked with an asterisk, Mr. Etheridge had some difficulty in naming the species :—

Nassa elongata.
Natica occlusa.
*Purpura lapillus, var. crispata.
Trophon antiquum (lower whorls).

———

*Anomia ephippium (1 small valve).
Cardium Parkinsoni.
Mactra.
Modiola modiolus.
Mya arenaria.
Mytilus edulis.
Panopæa ?
Pecten opercularis.
Tellina.

———

Balanophyllia (fragment).
Pollicipes.

W. W.

CHAPTER 6.—GLACIAL DRIFT.

GENERAL REMARKS.

The various beds massed under the heading "Drift" are perhaps the most important in our district, forming as they do some four-fifths of the surface, though often of no great thickness. The great mass of this area consists of what is known as "Glacial Drift," which was deposited at a period when glacial conditions prevailed in this part of England. A very small part of the Drift, however, is of later age, and known as "Post Glacial."

In many cases it is a difficult matter to determine the age of a mass of gravel, brickearth, &c., and in some cases our classification must be taken as doubtful; but these will be duly noticed.

A Memoir like this, descriptive of a limited area, is hardly the place for an essay on the classification of these beds. The threefold division proposed by Mr. S. V. Wood, junr., is well known, and indeed is the only systematic division of the Glacial Drift in East Anglia. Without entering into its merits, it is enough now to say that of the "Lower Glacial" of that geologist no sure sign has been observed here, though perhaps some of the beds included by us with the series which he has named "Middle Glacial" might be classed with the lower divisions by him. Until the work of the Geological Survey in Norfolk and Suffolk is in a more advanced state, it is better for us not to commit ourselves to a scheme of classification, and to be content with the detailed mapping of the beds and their lithological description. Speaking roughly we may here divide the Glacial Drift into two, the equivalents of the Upper and Middle Glacial of Mr. Wood, the lower consisting essentially of gravel and sand, and the upper being the great deposit of Boulder Clay.

Before proceeding to the description of the older or Glacial Drift of the district it will be convenient to notice a small deposit of pebble-gravel that occurs on the London Clay hills between Hertford and Hoddesdon, and which may be of Pre-Glacial age. It is composed almost wholly of pebbles, the larger mostly of flint, and the smaller of quartz, and it has been inferred to be the oldest Drift-bed in the district (and to the west), and to have been largely denuded before the deposition of the succeeding bed. All that is known of it with absolute certainty is that it is older than the Boulder Clay (which occurs over it in other parts), and Mr. S. V. Wood, junr., has classed it with his "Middle Glacial."

GLACIAL GRAVEL AND SAND.

These beds are of varying composition, from very coarse gravel to fine sand; sometimes with valuable deposits of loam, and with layers of Boulder Clay (or clay with glaciated stones) not to be distinguished from the thick mass of such clay that comes on above.

The stones composing the gravel are of many sorts, flints being the most common; but pebbles of flint, quartz, and quartzite are plentiful. Pebbles of hard chalk abound locally, and sometimes there are pieces of pudding-stone or greywether-sandstone (of Eocene age) and of septaria from the London Clay. In a list "of the Mineral Substances, and of the (derived) Organic Remains, found in the Gravel at Stanway, Essex, and . . . . within a Radius of Fifteen Miles," published by the late Mr. John Brown, of Stanway,* a great variety of rocks are noticed, which must be chiefly from Glacial gravel.

In some sections there are no signs of bedding; in others, the beds are roughly stratified, and in some the sand is finely bedded. False bedding (current-bedding) is common.

The gravel and sand are sometimes cemented into hard masses by ferruginous or calcareous infiltrations, and this is especially the case just under the Boulder Clay, the junction of the two deposits being often marked by a hardened surface of sand or gravel.

No fossils have been found in these beds but those derived from older formations, in our district, except at one spot, south of Thaxted, where Mr. Penning found two small shells, and some fragments, in gravel. These shells were submitted to Mr. S. V. Wood, who has determined them to be *Venus fasciata*? and *Astarte compressa* (young). Mr. S. V. Wood, jun., writes to me that "both species are the commonest of all the shells in the Middle Glacial of Hopton (near Yarmouth), and both also occur at Billockby; whilst *Venus fasciata* is extremely rare (almost unique) in the Red Crag." This puts aside the supposition that the shells may have been derived from the Crag, and supports the view that they belong to the bed in which they were found. The discovery is the more interesting, as it is not until we go far eastward, beyond Ipswich, that shells have been found in these beds, and none are known further west.

W. W.

Many of the valleys running S. and E. from the Chalk escarpment are, almost to their source, cut through Boulder Clay, and expose beneath it the gravel and sand. This series appears to be persistent over a large area, within which it is a rare occurrence for the Boulder Clay to be seen resting on the Tertiary beds or the Chalk. For it is probable that the gravels extend beneath the clay over nearly all the intervening area, in greater force, perhaps, along the lines of the larger valleys, and in a more attenuated or even patchy condition under the higher grounds. But in no instance do they run up to the top of the Chalk range, neither do they occur on the N.W. face of that escarpment.

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* *Mag. Nat. Hist.*, vol. viii. pp. 349–353 (1835). *See also ibid.*, n. ser., vol. i, p. 145.

W. H. P.

These deposits are found in nearly all the valleys of any importance S. and E. of the Chalk escarpment, running up to the places named below, beyond which the Boulder Clay rests upon the Chalk, without any gravel or sand between.

The Rib Valley, to Buckland.
" Ash " " S. of Brent Pelham.
" Stort " " Bearden and Elsenham.
" Chelmer " " N. of Thaxted.
" Ter " " Peak Hall, E. of Felstead.
" Guith " " above its source, near Great Bardfield.
" Pant " " Radwinter.
" Colne " " Ridgewell.
" Stour " " Haverhill.

It will be convenient, therefore, to describe the sections according to the valleys in which they occur, beginning at the head of each and working downward.

W. W. and W. H. P.

Valley of the Lea.

Along the high road, a little south of Hertford Gaol, there is some Boulder Clay in the gravel.

The following notes of the section in the great brickyard between Ware and Ware Park were taken in 1869. The whole of the beds were not shown at any one place, but their order seemed tolerably definite (though the divisions were not always clear) and as below :—

	a. Boulder Clay; a little, at the most north-easterly pit only (abandoned).
	b. Brown and buff sand, in parts (western side), sometimes gravel.
Brick-earth beds, sometimes not divisible; 25 feet or more.	*c.* Brown loam, with dark grey layers; 10 to 12 feet seen. *d.* Grey sandy clay; 8 to 10 feet, less in parts. *e.* Brown laminated clayey sand, with thin blocks of concretionary sandstone at or near the bottom.
Gravel and sand.	*f.* Sand, also with concretionary sandstone, sometimes with gravel; 8 feet seen. *g.* Gravel, with sand.

Chalk seen low down on the western side.

In parts the gravel and sand at the bottom rise up in a ridge nearly to the surface of the ground, and the accompanying figures (8, 9, p. 35) serve to show the irregular position of the beds.

In a pit just E. of Ware Union the gravel was seen to be hardened at the bottom.

At Widbury Hill, E. of Ware, there is a layer of Boulder Clay in the gravel, just up the lane running eastward.

On the hill more than half a mile nearly north of St. Margaret's station, is a small gravel-pit, just south of an old one that is marked on the Ordnance Map. The ditch above shows Boulder Clay over gravel, and the pit itself 12 feet of the latter over clay of the Reading Beds.

A little more than a mile N.E. of the Station there is some buff laminated loam with chalk pebbles (? rising from under the Boulder Clay).

Valley of the Rib.

The gravel-pit on the south-eastern side of the side-valley, a little east of the high road, a mile S.S.E. of Buntingford church showed (1873) a little

Fig. 8.—*Section at the W. Part of the Brickyard between Ware and Ware Park* (1869).

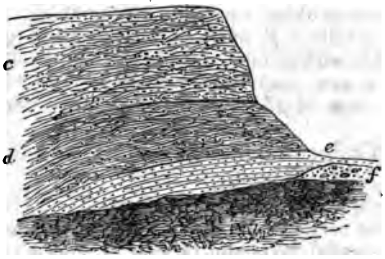
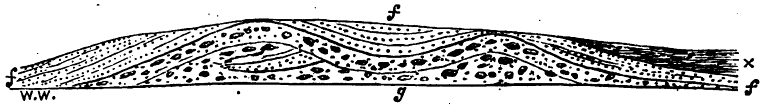


Fig. 9.—*Section along a Roadway in the Brickyard northward of Fig.* 8. (1869).



About 150 feet long and 14 feet deep at the most. The beds above have been worked off.

× Wash of loam, &c.
The other references the same as in the general section (p. 34).
c. Brown loam.
d. Grey sandy clay.
e. Brown laminated clayey sand.
f. Sand.
g. Gravel.

whitish Boulder Clay, slightly scooping into gravel, rather fine at top, but coarse lower down. There is a large block of conglomerate close by, and other smaller blocks lie about.

In the railway-cutting just N. of Westmill Station, there is chalky Boulder Clay and chalky gravel over Chalk-with-flints.

On the right bank of the stream, eastward of Knight's Hall, a pit showed 20 feet of gravel.

About a third of a mile westward of Stondon Church there is gravel with Boulder Clay and loam.

W. W.

At the brickyard, half a mile N.E. of Stondon, there is sandy loam, on yellow sand, with some pebbles in patches, 10 feet thick.

A pit a quarter of a mile N.E. of Stondon Lodge is in gravel of small quartz, flint, and other pebbles, with an intercalated bed of hard yellow sand, 7 feet thick.

The cutting for a new road from "Barrack" to "Moat Farm," Much Hadham, and just east of the former place, gave the section shown by Fig. 10, p. 37:—

A pit just N., of Timber Hall, Thundridge, gave the following section :—

Glacial Drift - { Gravel, 3 feet.
Loam (in places), a foot.
Chalk, its surface very uneven and with small patches thereon of green-coated flints and pebbles in greenish sand - }

"At Hare Street, in the valley of the branch called the Quin, a brickyard showed 10 feet of brickearth under gravel, close to the hamlet.

"The brickearth was also dug at another kiln about a quarter of a mile N.W., by the lane to Alswick Hall, and between the two kilns."*

Valley of the Ash.

The gravel in the pit S. of Hadham Ford consists chiefly of pebbles, with some subangular flints and patches of yellow sand, to a depth of 16 feet; and in that half a mile N.W. of Little Hadham Church it is of the same description; 10 feet exposed.

A junction of the Boulder Clay and underlying gravel is shown in a small pit on an occupation-road, S. of Berry Green.

In a Pit N. of the road from Hadham to Perry Green, and half a mile E. of Hadham Cross, there was gravel, iron-stained in places, and with small patches of sand to a depth of 12 feet. Boulder Clay was seen in the road towards higher ground on the E.; the Reading Beds with pebbles towards the valley on the W.; and Chalk in a pit below.

A road-cutting half a mile N. of Widford, exposed 10 feet of yellow sand and 8 feet of pebbly gravel.

A gravel-pit, half a mile W. of Widford Station, shows subangular stones and pebbles in a coarse sandy matrix, to a depth of 12 feet.

W. H. P.

Valley of the Cam.

The outcrop of the Glacial gravel in this valley is continuous with that of the Stort valley, from Quendon and Henham in the former to Stansted and Elsenham in the latter; but whilst the Stort cuts into this gravel along its whole length, the Cam shows it as a continuous mass only so far as Audley End.

W. W.

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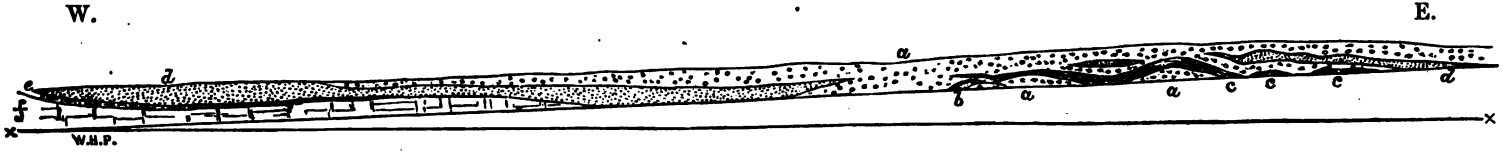
* From Mr. F. J. Bennett's Notes.

Fig. 10.—*Section along a Road-cutting* 1½ *miles N.E. of Thundridge (near "Barrack")*, 1871.



Scale, horizontal and vertical, 60 feet to an inch.
Inclination of the road about 1 in 30 westward.

Glacial Drift { *a.* Gravel with intercalated patches of sand (*b*), and a contorted bed of Boulder Clay (*c*).
d. Light-coloured sand, with a little gravel (*e*) below.
f. Chalk.
× Horizontal line.

The *d* on the right hand should be *b*.

The gravel-pit just S. of London Wood, E. of Quendon, gave the following section:—

Boulder Clay.
Chalky gravel, 3 feet.
Sand, mottled brown, white and yellow, 6 feet.

The section by the railway-bridge, half a mile south of Newport Station, is as below:—

Boulder Clay - } overlapped by valley gravel, which extends down to (or
Gravel - } under) the alluvium.

At Wicken Bonnett a gravel-pit S.W. of the church gave the following section:—

Glacial Drift - {
Gravel, with small patches of sand, and very sandy at the lower part, 18 feet.
Layer of grey clay, 3 inches.
Clayey sand, full of small stones, 6 feet.

The beds are bent, as shown by the clay layer, into an arch, probably by the dissolving away of the Chalk beneath. A pit to the W. of the above was all in gravel.

A well at the farm opposite is said to have been sunk through 40 feet of gravel and quick running sand very difficult to sink through.

Another well, E. of the Rectory, passed through 20 feet of gravel to Chalk, while at the W. end of the village the gravel is absent and the Boulder Clay rests directly on the Chalk.

A pit, three-quarters of a mile E. of Newport, on the S. side of a lateral valley, gave the section below:—

Boulder Clay, light-coloured at top, grey in the middle, and brownish at bottom, with intercalated patches of sand and Chalk; 18 feet.

Gravel, subangular and in a sandy matrix; and fine light-coloured sand in nearly level beds; 16 feet.

The Boulder Clay rolls suddenly over the gravel northwards, towards the valley, on the W. side of the pit.

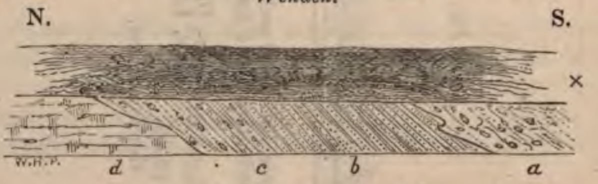
In another pit on the opposite side of the valley, and a quarter of a mile N.W. of the last, 10 feet of similar gravel and sand are exposed, with the Boulder Clay coming on just above.

A pit in the meadow S. of Debden Parsonage showed the following succession:—

	FEET.
Boulder Clay - - - - - - -	3
Brown false-bedded sand, with patches of small pebbles -	5
Greenish yellow sand, in places iron-stained - -	2
Light fine false-bedded sand, darker below, (not bottomed) -	5

The railway-cutting north of Audley End Station (Fig. 11), shows between two beds of Boulder Clay a hard yellow loam, which is probably the bed met with (but described as sand) in sinking a well 200 yards E. of the station (*see* p. 80).

Fig. 11.—*Cutting on the Great Eastern Railway, just N. of the Bridge at Wenden.*



Scale, 20 feet to an inch. × Overgrown.

Glacial Drift. {
a. Boulder Clay.
b. Hard yellow loam, passing into the bed below.
c. Boulder Clay.

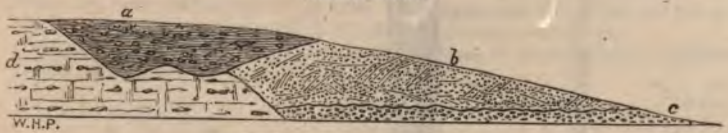
d. Chalk.

The cutting on the Saffron Walden Railway, about three-quarters of a mile from the junction with the main line, gives a deep section of the Drift, each bed of which is in considerable thickness, the succession being as follows :—

Glacial Drift. Boulder Clay.
Gravel and Sand.
Boulder Clay.
Chalk.

The pit by Kelk's Bridge, N.E. of Wenden, is in gravel, 8 feet deep, in places hardened at the top by calcareous infiltration, and overlain by a little Boulder Clay.

Fig. 12.—*Cutting on the Saffron Walden Railway, a mile N.E. of Audley End Station.*



Scale, 60 feet to an inch.

Glacial Drift.
a. Chalky Boulder Clay.
b. Light-coloured false-bedded sand.
c. Coarse gravel.
d. Chalk with flints.

Another section, in the railway-cutting on the Saffron Walden Branch, (Fig. 12) well illustrates the manner in which Drift deposits sometimes occur and the difficulty in accurately defining them where no good evidence is to be found. The rough gravel is banked against a Chalk slope, and is succeeded by whitish false-bedded sand. The last has been partially scooped away and the hollow filled by Boulder Clay which is very chalky, in fact so much like Chalk in appearance that at first sight the section seems to show sand going in under the Chalk.

The Drift hereabouts fills an old channel, one slope of which is shown in the above section, whilst another slope in a different direction and at a distance of half a mile is exposed near the station.

In the cutting S.E. of Chesterford Station there is a considerable thickness of fine sandy laminated loam, very much contorted, and dipping S. at about 12° under a lenticular patch of chalky gravel (4 feet), and near the bridge it seems to go under a mass of clay, which may be Boulder Clay or a wash from that deposit on the higher ground in the neighbourhood. This loam is therefore of doubtful age, being either Glacial or Post Glacial.

Valley of the Stort.

At Sandpits Farm, Elsenham, fine white sand is dug for "silver sand."

"About a third of a mile a little E. of N. of Bishop's Stortford Church there is some Boulder Clay over the sand and gravel."*

In a gravel pit, 300 yards S. of the Church at Bishop Stortford, the following succession of beds was seen :—

		FEET.
Glacial Drift.	Gravel and sand, very irregular - - - -	6
	Finely-bedded yellow sand with clayey patches - -	2½
	" white " " " " " - -	1
	Yellowish sand, passing down into white soapy clay -	2½
	Yellow false-bedded sand - - - - -	2
	Course white sand, with small angular flints, quartz and other pebbles - - - - - -	1
	Yellow sand, with a few small rounded and angular stones	4

A pit, N. of "Havers," S. of Bishop Stortford, showed the junction with the Boulder Clay, the section being :—

Boulder Clay, 6 feet.

Subangular gravel, with some pebbles of quartzite and other rocks, and patches of white and yellow sand, also some finer gravel stained black by manganese ; 14 feet, (not bottomed).

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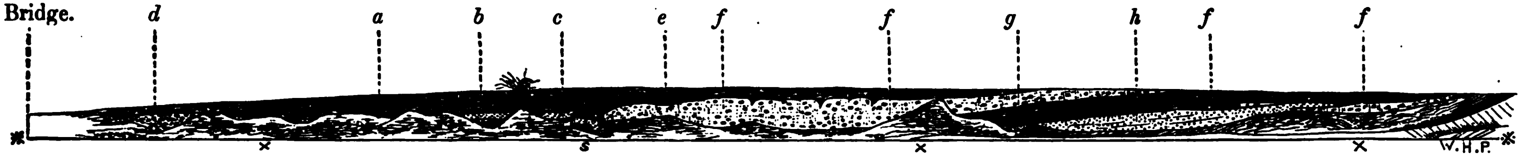
* From W. Whitaker's Notes. The clay may be a slipped mass.

Fig. 13.—*Southern Side of the Cutting on the Great Eastern Railway E. of Harlow Station,* 1871.

Scale, 80 feet to an inch.



* Level of siding. × Talus. S. Slipped Mass.

Post Glacial Drift.
- *a.* Brown brick-earth.
- *b.* Yellow loam, passing into the bed below.
- *c.* Grey sand.
- *d.* Gravel (Horn of Red Deer).

Glacial Drift.
- *e.* White loamy Boulder Clay.
- *f.* Chalky gravel.
- *g.* Boulder Clay.
- *h.* Light-coloured sand.

In a pit on the eastern side of the road E. of Hasler's Farm, S.S.E. of the same town, there was a thickness of 20 feet of gravel, like that at Havers.

A pit in the small patch just W. of Porter's Green, shows the gravel sticking up through the Boulder Clay.

In a pit just W. of Sawbridgeworth Mill, there is gravel and sand with black patches, similar to the beds in the Harlow railway-cutting.

There is a small pit at the cross-roads, half a mile N.E. of Harlow Church, in fine, light-coloured, laminated clayey sand; another pit at the N.W. corner of More Hall Park, Harlow, 12 feet in gravel; and another a quarter of a mile W. of Hubert's Hall, 10 feet in similar gravel with patches of coarse red sand.

The railway-cutting near Harlow Station (Fig. 13) exposes a good example of the Boulder Clay which sometimes occurs in the Glacial gravel and sand. This clay here differs somewhat from the Upper Boulder Clay, in being more chalky, almost like marl, and in containing no large boulders.

A gravel-pit S. of Pole Hole, about 1½ miles N.W. of Harlow, showed the following section:—

	FEET.
Yellow sand - - - - - -	3
Boulder Clay - - - - - -	3
In one part a few inches of white sand with black patches.	
Fine yellow sand with a little grey loam - -	3
Fine rolled and sub-angular gravel in sandy matrix	14

In a pit to the N.E. there is gravel with patches of sand 20 feet deep.

A gravel-pit N.E. of Gilston church showed 3 feet of Boulder Clay over 12 feet of gravel, of flint, quartz, and other pebbles.

A pit just S.W. of Netteswell Cross is in gravel and false-bedded light-coloured and yellow sands.

Gravel-pits N. of Parfolt's Green, Latton, passed through 5 feet of very chalky Boulder Clay, overlying 9 feet of gravel, of flint, quartz, and other pebbles, fine towards the bottom, and with a lenticular bed of yellow sand a foot thick.

Half a mile N. of Eastwick, by the road, Boulder Clay rests on fine white sand, and at a lower level there is yellow sand, loam, and pebble-gravel (? Reading Beds).

From Hunsdon and Stanstead Abbots to Widford is an outcrop joining that of the Ash Valley to those of the Lea and Stort Valleys. At an old brickyard a quarter of a mile N. of Hunsdon Street there is brown loam (Post Glacial?) over Boulder Clay, over pebbly gravel; and a pit half a mile W.N.W. of Hunsdon Street showed 5 feet of very pebbly gravel. A gravel-pit S.W. of Stanstead Bury, Stanstead Abbots, passes through Boulder Clay to angular gravel with some pebbles and a little yellow sand, 10 feet deep.

There is an exposure of sand and gravel high up the tributary valley of the Pincey Brook, a pit by "New Pond" in Hatfield Forest giving the section below:—

Boulder Clay, 4 feet.
Hard yellow sand, a lenticular patch, with thin patches of pebble-gravel on the top, 2 feet.
Fine light-coloured sand, 5 feet.

Valley of the Bourn.

A chalk-pit a mile S. of Bartlow Station shows the following succession:—

Boulder Clay, 2 feet; passing down into
Clayey sand with stones, a foot to 2 feet;
Hard crystalline band, 3 inches;
Chalk with flints and thin marly layers.

W. H. P.

CHAPTER 7.—GLACIAL DRIFT (*continued*).

GRAVEL AND SAND.

Valley of the Roding.

Near the head of this valley fine quartz gravel and yellow sand crop out from beneath the Boulder Clay for some way both N. and S. of Little Canfield, and may be seen in a pit just W. of Little Canfield Hall.

Valley of the Chelmer.

The brickyard and gravel-pits a quarter of a mile N.W. of Thaxted give the following section:—

Glacial Drift	Boulder Clay 4 feet. Gravel, ferruginous at bottom, and containing ironstone concretions; 7 feet.

London Clay, somewhat sandy, brown.

A pit half a mile E.N.E. of Thaxted Church showed the junction with the Boulder Clay, the section being:—

	FEET.
Brown wash - - - - - -	3
Boulder Clay - - - - - -	2
A very thin band of light-coloured crystalline sandstone, being the upper surface, cemented by carbonate of lime, of the underlying bed.	
Fine white, false-bedded sand, with occasional small pebbles - - - - - -	7

From a sandy bed in a gravel-pit S. of Thaxted were taken some shells of *Venus* and a small *Astarte* (*see* p. 33).

In a small pit just S. of Dove House Farm, a fine gravel with coarse sand, ironstained and with highly-inclined bedding, rests on horizontal yellow sand.

A gravel-pit S.E. of Buckingham Folly, 1½ miles S. of Thaxted, again showed the junction with the Boulder Clay:—

Boulder Clay, in a hollow, cutting out and passing down into
Light-coloured loamy sand, with calcareous concretions.
Gravel.

A small pit three-quarters of a mile N.E. of Tiltey Church showed fine gravel and yellow sand, with iron-shot bands in the bottom half, 5½ feet, over gravel, 7 feet.

Another small pit, on the northern side of the road at Duton Hill, showed coarse yellow sand, 3 feet; dark brown sand, ½ foot; gravel, of subangular flints, and flint and other pebbles, 2 feet; coarse yellow sand.

In a pit at Hyde, 1 mile W. of Lindsell, the following section was seen:—

Boulder Clay, 2 feet.
Light-coloured rather coarse sand, 1 to 2 feet.
Gravel, of subangular flints, and flint and other pebbles.

The gravel-pits south of the road, a quarter of a mile N.N.E. of Little Easton Church gave the section below:—

	FEET.
Gravel - - - - - -	3
Dark brown hard clay, with lumps of chalk, &c. -	1½
Yellow gravel - - - - -	3½
Whitish chalky gravel - - - -	4

A little further south was a section showing Boulder Clay above gravel, the former conforming roughly to the fall of the ground, and sharply wrapping over the latter.

Half a mile E. of Little Easton is a pit showing pebble-gravel, 2 feet, coarse dark brown sand, a foot, and a very fine yellow sand, 4 feet.

A ballast-pit by the side of the railway-cutting, half a mile W. of Dunmow Station, gave the following section. The sands are false bedded, the lines trending eastward; the beds were observed and noted as they succeeded each other along the N. side of the section, but no thicknesses could be taken:—

Boulder Clay (by the bridge over the line).
Reddish and mottled clayey sand with pebbles (in places only).
Fine gravel of rolled quartz pebbles, few flints.
Yellow and whitish sand, with patches of whitish clay (thickens eastward).
Fine gravel of rolled quartz pebbles.
Yellow and whitish clayey sand.

W. H. P.

At Hartford End the slopes of London Clay on both sides of the valley are so thinly spread with gravel as to render it a matter of opinion whether the latter or the former should be mapped as forming the surface. At some points the gravel is wanting; at others it is several feet thick, the surface of the clay being extremely irregular. West of Warner's Farm a small gravel-pit cut across a spur of the Boulder Clay, of which a lenticular cap, nowhere more than 18 inches thick, remained on the eastern side of the pit, but is probably now removed.

At the sharp angle of the road northwards of How Street there is some thickness of loam. At How Street the gravel is cut off by a rising up of the London Clay, and a depression of the Boulder Clay. Near Great Waltham Church the gravel is more than 24 feet thick, and in a well at Langley's in the adjacent park, and at a lower level, 15 feet of gravel were found over 6 feet of sand, resting on the London Clay. On the western side of the park are several deep overgrown pits, the gravel of which contains pebbles of chalk. Similar chalky gravel occurs at the N.W. corner of the park.

A lenticular patch of Boulder Clay occurs in the gravel at the junction with the high road of the lane leading from Little Waltham to Broad Green, and the London Clay is stated to be within a few feet of the surface at the adjoining cottages.

In a well a quarter of a mile W. of Blasted Hill, 8 feet of Boulder Clay covered 12 feet of gravel, whilst at the windmill a little N.W. of the 32nd milepost, gravel has been proved to 20 feet without being penetrated, and not starting from the top of the bed. In wells at Scravels, near Broomfield, there are 12 feet of gravel, and at Broomfield School 18 feet, covered respectively by 3 and 7 feet of Boulder Clay. The gravel is traceable up the tributary Cann valley to above Chignall Hall. A large overgrown gravel-pit occurs at Porters. Another pit near Stevens, open in 1872, showed well-stratified gravel, with a bed about a foot thick cemented into a rock, whilst across these came a bed of loam with chalky grains at the base, in marked unconformity.

Valley of the Ter.

At Willows Green Farm the gravel is only a few inches thick, but it increases to 4 or 5 feet on Willows Green, and to over 20 feet on the south-east. At Leigh's Priory, where it has been dug in several places, it has a considerable thickness.

West of Great Leighs a lenticular mass of Boulder Clay lies at its base, and a similar patch occurs at Ridley Hall, between which and Terling two more masses occur in the body of the gravel. At Great Leighs Parsonage the gravel is 20 feet thick, and 5 furlongs east over 30 feet under a like thickness of Boulder Clay. At Weleigh Hall, 2 miles N. of Terling, the gravel is absent at the head of the tributary valley; at a quarter of a mile N. of Fairsted it is about 10 feet thick, and at Fairsted Rectory over 50 feet, as proved by wells.

At Terling the gravel is extremely variable in thickness. At the farm S. of Hatfield Wick it was 36 feet thick in a well near the edge; here, therefore, the gravel must fill a hollow in the London Clay.

About Hatfield Green there is loam, probably very thin, but continuous with the gravel and sand under the Boulder Clay to near Witham.

W. H. D.

Valley of the Guith.

A pit, N. W. of Shalford Pond Green showed 12 feet of yellow sand, with thin bands of brown hard sand.

A pit just E. of Jesper's Green was in gravel over yellow sand, and another, 200 yards N., in light-coloured pebbly gravel (flint, quartz, &c.).

A pit N. of Great Saling Church showed gravel, of subangular flints, flint and other pebbles in coarse yellow and iron-stained sand, 6 feet, over yellow and light-coloured sand.

A small pit west of Pound's Farm is in light-coloured pebbly gravel and sand.

A pit just S. of Rayne Station is in pebbly gravel (flint, quartz, &c.) with patches of coarse yellow and grey sand, 12 feet. By the milestone on the road to Braintree another pit shows 8 feet of red sand and gravel, and half a mile S. of Braintree Station is another, 10 feet, in coarse red and yellow sand with occasional pebbles, whilst just S. of the station there is sandy gravel.

W. H. P.

South of Braintree the gravel descends nearly to the alluvium, its bedding conforming to the slope of the surface, which is rather steep; though this may be partly due to falling over.

The sandy layers contain ironstone-nodules and some of the gravel is cemented by oxide of iron into a tolerably coherent rock, used in some of the older buildings of the district.

The brickyard, a quarter of a mile S.S.E. of Hoppit Bridge, Braintree, has been worked so irregularly as to prevent any clear insight into the arrangement of the various deposits of brick-earth, sand, and gravel exposed in the many small excavations; the deposits were seen, however, to be very irregular.

At Cresing there is an inlier of gravel near the church, W.N.W. of which, in a well at Whitehead's Farm, the gravel was found to be over 30 feet thick, under 28 feet of Boulder Clay. On the railway near Bulford Station the gravel is but 6 feet thick.

At Faulkbourn Rectory the gravel is 18 feet thick and opposite this place it reaches down to the alluvium, but strong springs that rise at that level show the occurrence of London Clay just beneath.

Sand rises up from beneath the Boulder Clay in the railway-cutting 1¼ miles southwards, and crops out as an inlier.

The railway-cutting on the Braintree Branch north-eastward of Chipping Hill passes through a small boss of gravel and sand, which does not rise to the level of the ground.

At Chipping Hill and Witham this gravel is absent, the Boulder Clay resting at once on the London Clay.

A pit just S. of Blunt's Hall, opposite Witham, showed Boulder Clay over sandy gravel, 7 feet deep.

W. H. D.

Valley of the Blackwater or Pant.

In the upper part of this valley, above Great Bardfield, the outcrop of the Gravel and Sand from beneath the Boulder Clay is continuous, and in the same line, with the outcrop along the valley of the Guith, whilst it is separated from that along the lower part by a narrow strip of Boulder Clay just below Great Bardfield.

At Braintree again the two outcrops join across the narrow neck separating the two valleys. W.W.

In a pit just E. of the windmill at Ash, Radwinter, gravel, 4 feet thick with an intercalated patch of light-coloured false-bedded sand (0 to 1½ feet), was seen to be underlain by fine light-coloured laminated sand, 3 feet.

A pit a quarter of a mile eastward of Radwinter showed 6 feet of gravel (the upper half discoloured and probably Post Glacial) overlying grey brick-earth. A stag's horn was found just at the base of the upper discoloured part of the gravel, 3 feet from the surface.

Another pit three-quarters of a mile E. of Radwinter, gave the section below:—

	FEET.
Boulder Clay	3
Brown Clay, free from stones	2
Fine chalky gravel	2
Subangular gravel	10

A pit 1¼ miles E.S.E. of the same village showed a like section, as follows:—

	FEET.
Boulder Clay	3
Grey clay, free from stones	2
Gravel	10

Three-quarters of a mile N.W. of Great Sampford is a pit in gravel 16 feet deep; whilst another pit, half a mile N.N.W. of that village, showed Boulder Clay over light-coloured, fine, and laminated sand, false-bedded at top, pebbly towards the bottom, 20 feet deep.

"On the left bank about Wethersfield, and thence S.E. to Codham Hall, there is mostly sand, into which some of the lanes are deeply cut, notably one from Rotten End to Beazley End.

"About half a mile out of Wethersfield, on the northern side of the road to Hedingham, a section was seen of 8 feet of chalky Boulder Clay over buff sand with hard consolidated bands."*

In a pit on the eastern side of the wood just S. of Shalford was yellow sand with thin bands of brown hard sand, 12 feet deep; whilst another pit, just S. of the last but on higher ground, was in gravel of flint and quartz pebbles, also 12 feet deep.

There is a small pit nearly opposite the E. entrance to Abbot's Hall, a mile S.S.E. of Shalford, showing—

	FEET.
Yellow sand	1
Course hard false-bedded sand in brown and grey alternating layers 3 inches thick	3
Light-coloured sand	2

A pit just S. of Baytree Farm, 2 miles E. of Braintree, gives the following succession of beds, their thickness being variable:—Pebbly gravel, coarse yellow and red sand, and yellow loam.

W. H. P.

Half a mile south-by-west of Bradwell 30 feet of gravel were found in a well below 40 feet of Boulder Clay.

In a pit near Hill Farm a quarter of a mile N. of Coggeshall Church the sand contained some layers of dark reddish-brown clay like weathered London Clay.

There is a little Boulder Clay at the bottom of the gravel near the river S.W. of Coggeshall.

From Feering to Witham, river-gravels occur in the valley (*see* p. 67), but no line of separation can well be drawn between them and the Glacial gravel, there being no lithological distinction. The thickness of the Glacial gravel north-west of a line from Feering to Chipping Hill averages 30 to 40 feet, and probably its absence in the valley is due to erosion before the deposition of the Boulder Clay, for the removal of that clay would not greatly alter the surface-configuration, and it is not likely that such valleys would be left merely by irregular deposition of the Glacial sand and gravel.

Just N. of Bencroft Farm (N. of Kelvedon) sand is touched in the bottom of an old pit in Boulder Clay. South of Priested Hall Wood the lane is cut through Boulder Clay into gravel, and half a mile N. by E. of Inworth church is a similar section.

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* From Mr. F. J. Bennett's notes.

A little E. of Inworth Hall there was in 1872 a large sand-pit, more than 30 feet deep, since filled up. Half a mile W. of the church sand is touched in the bottom of a Boulder Clay pit. South and east of these sections the Glacial gravel is absent, the Boulder Clay lying directly on the London Clay.

At Crabes Farm, Kelvedon, the Glacial gravel comes out from under the Boulder Clay, but the junction is overlapped by the river gravel.

Wells show that at Marylands there are at least 27 feet of gravel and sand, and near Rivenhall Place 17 feet, under 30 and 20 feet respectively of Boulder Clay. Inliers occur in the tributary valleys on the right bank of the river N. of Felix Hall, and S.E. of the same place, where a pit near the Lodge showed gravel and sand under Boulder Clay; and at Rivenhall Place, where, on the north of the park, the gravel contains an unusual number of Secondary pebbles (other than flint), and west of the park the junction with the Boulder Clay was seen.

On the west of the lane south of Hill Farm, Wickham Bishop, is an old overgrown pit, which Mr. S. V. Wood, junior, tells me is in Boulder Clay. This must be a lenticular bed at or near the base of the Glacial gravel. Some clay, like London Clay, occurs in the lane close by. Other patches of Boulder Clay, too small to map, have been found in the adjoining fields.

Tiptree Heath.

This ridge is capped to a great extent by gravel, often thick. The south-eastern slope is mostly free from gravel, but on the north-west there are many patches and irregular strips. In some pits just W. of Great Totham Windmill gravel and sand are shown to a depth of 20 feet.

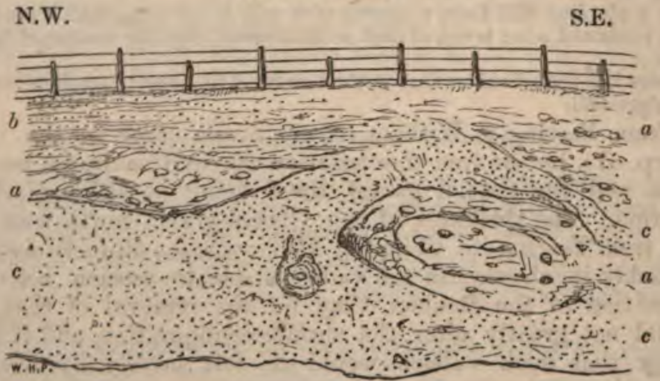
W. H. D.

Valley of the Colne.

A small pit, just N.W. of "Wash," one mile W. of Ridgewell, shows Boulder Clay overlying gravel; and in another pit, N.E. of Ridgewell church, the clay is exposed resting on chalky gravel.

The railway-cutting a mile N.W. of Great Yeldham gave the section shown in Fig. 14, in which is seen a rolled-up mass of Boulder Clay embedded in the gravel. Clean loam occurs in the cutting a little further S., but it is not clear whether it is represented in the upper part of this section.

Fig. 14.—*Part of Cutting on the Colne Valley Railway, a mile N.W. of Great Yeldham.*



a. Boulder Clay. *b.* Loam. *c.* Gravel.

A quarter of a mile N. of Great Yeldham church was a pit, in fine gravel, false-bedded and contorted, with an intercalated bed of Boulder Clay, 1 to 1½ feet thick. This bed of clay is seen also in an old gravel-pit between the above and the church.

Just S. of the church is the following section :—

	FEET.
Brown loam	3 to 4
Buff sand	1½
Hard brown loam	3
Light-coloured loamy sand.	

On the other side of the stream gravel occurs, at least 10 feet thick, and in the channel of the stream from the W. there is Boulder Clay.

These deposits of gravel and loam may be Post Glacial, but there is no evidence to call for separating them from the undoubted Glacial deposits on every side.

S.E. of Yeldham Station is a pit in fine gravel, with but few large stones, said to rest on a lower Boulder Clay, and this again on a darker clay.

W. H. P.

The railway-cutting south of Yeldham Station is mostly overgrown. The southern part seems to be all in Boulder Clay, but before getting to the bridge over the line there are signs of a thin sandy gravelly bed in the clay, causing dampness and slips. This reaches northward of the bridge, is about 3 feet thick, and seems to sink further on. On the western side, at about 80 yards beyond the bridge, there is a hollow of clean grey clay, with buff loam below, over gravel; whilst a few yards further there is Boulder Clay over sand and gravel, hardened at the top. The eastern side has been reopened about 100 yards north of the bridge, and dug some feet below the level of the line: the Boulder Clay ends off at once, apparently abruptly, and from beneath it there rises up sand and gravel over 25 feet thick, false-bedded, somewhat contorted, of a buff colour, and with thin lenticular layers of Boulder Clay. The sand is very fine and partly clayey, the gravel mostly fine but with one coarse layer, and there is an apparent dip northwards. This fine section is of interest as showing layers of Boulder Clay in various parts of the sand and gravel.

W. W.

The cutting southwards, south of Lovington, shows a hollow of Boulder Clay, over gravel and very fine soft sand and loam, and in one part gravel seems to overlie a bed of Boulder Clay.

The next cutting, about a mile from Hedingham Station, passes through gravelly soil, over laminated light-coloured sandy brickearth, over false-bedded sand and gravel; and the next, northwards of Nunnery Street, shows at the northern end Boulder Clay scooping into chalky gravel; whilst in a field to the east and close to the lane a pit showed 8 feet of coarse false-bedded sand.

The cutting between Nunnery Street and the station shows gravel over grey loam, which latter has been worked in the field on the east.

About two thirds of a mile S.S.W. of Hedingham Station laminated sand and clay overlying false-bedded sand, in all from 15 to 30 feet thick, were seen on the eastern side of the road.

At the back of the Lamb Inn, Sible Hedingham, was a pit 7 feet deep in fine pebbly gravel, with much quartz; and nearly opposite the Black Horse Inn was another, 12 feet deep, in fine buff sand, over which southwards came gravel, whilst further on a lenticular mass of Boulder Clay came between the two, resting irregularly on the sand.

At Southey Green, Boulder Clay was seen over sand and gravel.

In the railway-cutting a mile northward of Halstead Station there is sand, 12 feet thick, capped by gravel, and also a little loam at one part.

At the edge of a wood, about three-quarters of a mile N.N.W. of Halstead Station, is a section of 8 feet of Boulder Clay, capped by sandy loam. This clay seems to be a bed in the sand, and it can be traced for some way southwards.

Just east of Halstead, on the northern side of the road to Colchester, a large pit gave the following section :—

At one part stiff brown clay with large stones, which may represent the Boulder Clay, up to 3 feet.
Rather coarse red gravel, bedded with layers of sand, 8 to 10 feet.

There were a number of large boulders in this pit, and a little to the north was another pit, 7 feet deep, in coarser gravel, with a lenticular mass of loam and irregular lenticular masses of sand, from the bottom of which very large flints have been got.

N.E. of the above, on the northern side of the road to Colne Engaine, a third pit showed sandy loam over coarse red gravel, with large flints and blocks of quartzite and other rocks, 7 feet deep.

Nearly half a mile S. of Ashfield Lodge, further northward, a pit gave the section below:—

A little gravel.	
Reddish sand - -	8 feet.
Rather coarse brown sand -	6 „

A pit just north of Colne Engaine church showed 4 feet of Boulder Clay over 8 feet of yellow sand, with a lenticular mass of gravel coming in between in places. Some small flints occur in the sand.

The tributary valley from Pebmarsh is cut through the Boulder Clay down to the London Clay. About a quarter of a mile N.E. of Pebmarsh church are some old pits showing Boulder Clay over pebbly gravel and buff sand. Southward of the church two pits in gravel and sand were noticed, one of these also showing the Boulder Clay above. Eastward of Spoons Hall the gravel rises up through the Boulder Clay in a boss.

In the larger tributary valley from Blackmoor End to Earls Colne the beds below the Boulder Clay are again laid open. Just S. of the former place, on the road to Hyde, a pit showed the Boulder Clay over reddish-brown gravel, 6 feet deep, and there are other gravel-pits along the valley. One of these, a little S.E. of Bouncer's Farm, in a side-valley, gave the section:—

Loam, 2 feet.
Reddish pebbly gravel, bedded and false-bedded, the upper part with reddish-brown sand interbedded, 10 feet.
Fine ochreous sand, dug at the lowest part.

A mile west of Gosfield Hall, in the angle of the roads, is a pit in gravel and sand;. whilst the brickyard just N.W. gives a section of bedded clay, the upper part of which is brown (from weathering) and rather sandy, the lower bluish-grey. On the N.E. of this, close to the stream, the blue clay is also dug.

At Earls Colne the gravel is dug, and in cutting a drain at the highest part of the town London Clay was reached, through gravel, at a depth of about 4 feet.

F. J. B.

CHAPTER 8.—GLACIAL DRIFT (*continued*).

GRAVEL AND SAND.

Valley of the Stour.

A pit about half a mile S.W. of Haverhill church gives the section below:—

Boulder Clay, thin end of; 6 feet.
Coarse gravel with large boulders.

This, being on the higher ground, is a boss of gravel sticking up through the overlying Boulder Clay.

A pit half a mile S.S.E. of Haverhill Church gives another junction with the Boulder Clay, the section being,—

Boulder clay: at the base, in one part, a large boulder of chalk and gravel; 10 feet.
Lenticular patch of brown sand, with a nest of pebbles; 6 feet.
Grey and variegated loam, with flint pebbles; 6 feet.

These beds are like Reading Beds rearranged.

The sand and chalk pit W. of "Burnt House," N.W. of Stoke, gives a fine section, upwards of 60 feet in height, and the sands weather irregularly in consequence of their varying hardness:—

	FEET.
Glacial Drift. White, grey, and yellow false-bedded sand, partly coarse, partly fine, irregularly bedded. A mass of shells (*Purpura lapillus*), said to have been found at the bottom at one spot (? Crag) - - - - - -	30
? Drift or Red Crag. Bed of flints, &c. (a piece of phosphatised bone) - - - - - -	1 to 2
Chalk, bedded, with flints - - - - - -	30

A pit just S. of the house in Baythorn Park, in a knob of gravel rising up through the Boulder Clay, shows 2 feet of the latter over 8 of the former.

A pit a quarter of a mile S.W. of Launds, Ashen, showed 8 feet of coarse angular hard gravel, much contorted. This gravel is exposed by the Boulder Clay having been partly deunded off the flank of the hill, on a lower part of which it still remains.

The pit N.E. of Ovington Hall was 10 feet deep in fine, rather chalky gravel, with thin bands of sand and loam, all much contorted.

On the top of the loamy beds ironstone concretions are being formed, from the downward percolation of water charged with iron being checked thereby.

The gravel-pit half a mile W. of Clare gives the following section:—

Post Glacial Gravel; a foot.

Glacial Drift.	Boulder Clay; 2 feet. Chalky Gravel, with small patches of light-coloured sand, both false-bedded, and a very thin evenly-bedded layer of sand; 14 feet.

The gravel under this hill appears all to be chalky; further W. (to the N. of Moor Hall and by Burnt House) it changes to a bright yellow sand; a sudden change in so short a distance.

The large pit half a mile W. of Chilton Hall, N.W. of Clare, is in coarse gravel, the pebbles chiefly flint, but there are some of sandstone, quartzite, &c., and many lumps of chalk, in a matrix of chalky sand, with some small patches of false-bedded sand, 18 feet deep. The lines of bedding are much curved, as shown especially by a layer of ironstone concretions, about the centre. The lower part of the gravel is very coarse.

Boulder Clay occupies the valley below this pit, but the evidence is not quite clear whether it is a lower bed, or a roll over of the Upper Boulder Clay into a hollow, from the flanks of which it was afterwards denuded: the latter seems the more probable explanation.*

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* In the lane just below this pit there is Boulder Clay, which seems to be under the gravel.—W.W.

A pit S.W. of Pentlow Street was in brown and yellow sand, finely laminated and false-bedded, with bright red sand and a thin layer of ironstone at the bottom, 11 feet thick, and underlain by 6 inches of bright yellow fine sand.

There is similar sand in a pit a quarter of a mile S.

Half a mile S. of Weston Mill is a pit 5 feet deep in chalky gravel with patches of grey sand. This is a hummock of gravel, from which the overlying Boulder Clay has been denuded.

"About half a mile E. of Cavendish Station there is a brickyard on the northern side of the road, a pit in which gave the following section":—

		Feet.
	A little loamy soil	5 to 6
Glacial Drift.	Layer of fine flint gravel, resting somewhat irregularly on the bed below	
	Loam with flints	
	Loam with a few flints	about 6
	Clay with small pieces of chalk (Boulder Clay)	,, ½
	Clean loam, without stones	to 6

"Only a few yards westward, and at the same level, was a pit in Boulder Clay."

"The greater part of Glemsford Street seems to be on gravel, which is of considerable thickness and may be seen in a pit on the brow of the hill about half a mile N. of the railway, where about 10 feet of it is shown, the lower part consisting of small angular flints in a gritty matrix, with pieces of chalk; the upper part being coarser and resting unevenly on the lower. A little lower down the hill is another old pit, with a pond in the bottom in Boulder Clay."*

There is a section, as below, in a cutting on the eastern side of the occupation road, along the N.W. side of Liston Hall Park:—

Whitish marl, fine and hard (? base of Boulder Clay) cutting out, and filling a hollow in, the beds below down to the gravel at the bottom.
Sandy marl.
Hard bed, 6 inches.
Whitish sand, coarse and chalky, a foot.
Hard bed, 6 inches.
Whitish sand, a foot.
Gravel.

At the brickyard just S. of Liston Mill the following section was noted:—

Post-Glacial. Brown loam, with fragments of land-shells in the lower part; 0 to 6 feet.
Glacial. Light-coloured false-bedded sand; 2 feet.
Chalk, seen in the well.

The Boulder Clay is exposed in a pit on the northern side of the road close by.

A little N. of Brook Hall, Borley, there is a gravel-pit showing Boulder Clay in a hollow, on fine false-bedded gravel and sand, 8 feet thick.

There is an outcrop along the side-valley of the Belchamps.

A pit northward of Bovington Farm, Belchamp Otten, showed the following succession of beds:—

Boulder Clay; 2 feet.
Fine chalky gravel; 5 feet.
Boulder Clay.

This last clay is the same as that which comes to the surface along the valley just below, and a small outcrop of which is again seen N.E. of Belchamp Walter.

There is a large pit a mile N. of Belchamp Walter church, 30 feet deep. The beds are very much contorted and false-bedded, and consist mostly of gravel at the top, of very fine light-coloured sand (hardened in places) in the middle, and of grey sand below.

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* From Mr. C. E. Hawkins' Notes.

In an old pond or cutting by the mill, near Belchamp Walter church the following beds were exposed: Post-Glacial loam and sand, 2 or 3 feet; Glacial gravel and sand, 1 or 2 feet; Chalk. The Boulder Clay comes on just above.
W. H. P.

In the tributary valley that joins at Long Melford, Boulder Clay and gravel may be seen in the stream-course about half a mile eastward of Lodge Farm, and a large pit about a quarter of a mile north of Acton Place gives the following section:—

A little coarse gravel.
A long mass of pale Boulder Clay, brownish at the bottom, up to 6 feet thick.
Gravel, mostly very coarse (when it is chiefly made up of large, more or less rounded flints), partly finer, and with some sand and loam occasionally, confusedly bedded, bare at both ends of the section, and at the east shown to a depth of about 30 feet.

In the park, on the other side of the little side-valley, Boulder Clay occurs from top to bottom, so that this gravel rises up in a mound from beneath the clay.

The southern part of the railway-cutting just east of Long Melford was quite hidden in 1873, but seemed to be clayey at the bottom at first, with apparently a rise of loam below Boulder Clay at the deepest part, and a little loam at top. Where the cart-track crosses the line, in a hollow, there is Boulder Clay. The ground then rises again, and the cutting is clearer at the highest part (and on the N.W. side), showing Boulder Clay with some small hollows of gravel and sand at top. Just before getting to the bridge over the line there rises up from beneath the Boulder Clay (which must be the bed in the midst of the sands and gravels) very fine soft buff sand, about 4 feet thick, and underlain by gravel. At the bridge this sand comes up to the surface. Beyond, the sides of the cutting are hidden, but at the end there is again Boulder Clay.

S.S.E. of Melford, up the side-valley to Newman's Green, gravel and conglomerate occur along the watercourse.

A little east of the high road from Melford to Sudbury, and south of the lane to Newman's Green, is an old pit in brickearth and Boulder Clay, both intercalated masses in the gravel.

The lane-cutting from St. Bartholomew's (Sudbury), south-westward, shows the following succession:—

A little Boulder Clay at top.
Layer of gravel in parts.
Light-coloured sharp sand, which soon dips down the lane, when the higher part is brown gravel.
Lower down everything is hidden by a thick wash of stony loam.

At the town of Sudbury there is a great number of pits in the Glacial Drift, many of them large and clear: indeed, I know of no inland sections where this series of deposits can be so well studied, not only from the above cause, but also by reason of the varying nature of the deposits and of the complicated way in which they often occur. When to this advantage is added the facts that there are fine sections of Chalk and Eocene Beds, that Crag has been found here, that there is also a fair development of fossiliferous Post-Glacial Drift, and that many of the pits are in constant work, it is clear that Sudbury is a place that should be visited by geologists, who have but one representative in the neighbourhood, my friend Dr. J. S. Holden, F.G.S.

The details of sections that will be given show the irregularity of the Drift here, and the impossibility of mapping the various divisions accurately on a map of so small a scale as an inch to a mile.

The full succession of the divisions of the Glacial Drift at Sudbury, combining the facts of all the best sections, seems to be as follows:—

1. Boulder Clay. The "Great Chalky Boulder Clay" or "Upper Glacial" of Mr. Wood.
2. Buff and grey laminated brickearth.
3. Gravel and sand.
4. Boulder Clay.
5. Sand and gravel.
6. Ferruginous sand. Possibly, in part at least, belonging to the Red Crag. Underlain by the nodule-bed of the Crag.

There seem, however, to be other local intercalations, as will be seen from a few of the sections to be noticed:—

The pit close to, and just southward of, the Sudbury Waterworks, on the north of the town, shows, at the highest part,—

Boulder Clay, with a brownish loamy stony layer; 6 feet or more.
Greensand: base of Thanet Beds; up to more than 2 feet.
Chalk.

Westward, towards the high road, a patch of brown sand with the pebble-bed at the bottom (Crag) wedges in between the clay and the greensand. North-westward, at the entrance to the pit, the Drift plunges down to the bottom of the pit, at angles up to 30°, and consists of pale Boulder Clay, passing down into brownish sandy bedded Boulder Clay, with sandy and stony layers (at one part more than 3 feet of buff loam and sand = the brownish bed above noted), over ordinary Boulder Clay. Just beyond the entrance the excavations for a new Malting again showed Boulder Clay.

On the northern side of the hollow N.E. from the town is a series of sections within a small area. There was a very small pit, only divided from Harding's chalk-pit, where Crag is the highest bed (*see* p. 31), by a footpath, and although at a slightly lower level it showed gravel over sand. Another very small pit a little further off and on the other side of Harding's pit (and somewhat below Webb's chalk-pit, also described on p. 31) showed Boulder Clay, over sand and gravel, over loam.

By the side of the footpath running N.E. to above the Alexandra Pit, and above those just noted, a larger pit gave the following section:—

Gravel and sand in a hollow (at N.E. end).
Brickearth.
Gravel and sand.
Boulder Clay, rising up sharply S.W., and fairly thick.
Crag ironstone and shells touched at S.W. end.

A shallow hole in the field close by (N.W.) showed a little Boulder Clay, over 2 feet of gravel, over other Boulder Clay, and from the pit was a cut (north-eastwards, by the path) in gravel and sand, with a hollow of brick-earth.

In the Alexandra Chalk Pit, by the road to Wood Hall there is a most irregular assortment of Drift beds. A little pit, close by the footpath at the top, showed gravel and sand over Boulder Clay; whilst the large pit gave the following section at its highest part:—

Drift.	A little gravel and sand. Buff loam and sand (= the laminated brickearth); 6 to 8 feet. Gravel, scooping into the beds below.
Crag (in two places.)	Ironstone. Layer of flint-pebbles and phosphatic nodules; up to 2 feet.
Thanet Beds.	Pinkish sand; up to 2 feet. At one point slightly cutting over the bed below. Clayey greensand, with green-coated flints, and with some ironstone at bottom; up to 2½ feet.
Chalk with a few flints.	

Nearer the road, on the south of the entrance, there is Boulder Clay, capped by gravel, over the greensand of the Thanet Beds, whilst on the other side the loam and gravel (contorted) rest on the Chalk, and further from the entrance the Drift consists of Boulder Clay, partly with gravel at the bottom, over the brickearth, over gravel.

On the hill N.E. of Sudbury there is a mass of laminated brickearth, believed by Mr. S. V. Wood, Jun., to represent the "Contorted Drift" of his "Lower Glacial," but which seems to me rather to be, as in other neighbouring sections, the top part of the "Middle Glacial." This brickearth, which forms rising ground above the sand on its south, is worked in two large brickyards, (1873–5). At the more easterly of these I saw a very long section of the buff laminated brickearth, to a depth of about 25 feet, and was told that it had been proved deeper.

At the southern end the brickearth dipped northward, and over it was a hollow of pale Boulder Clay. From this part the former rose up sharply and ran (with nearly flat bedding, but with a slight arch) to the northern side, the whole of the section being in it, and its base being grey. It is of particularly clean character, with few stones or concretions.

At the eastern edge of the yard, by the kilns and farmyard, a shallow hole showed at one part a little pale Boulder Clay, overlying, and within little more than a foot of cutting through, the brickearth, from beneath which there rose up (but not to the surface) a dome of sand and fine gravel, from a foot to 2 feet thick, and underlain by Boulder Clay, so that the succession seems to be the same as at the old brickyard about half a mile southwards, described below.

At the other brickyard, to the west and facing the road that runs N.E. from Sudbury, the higher pit showed a capping of Boulder Clay, up to about 10 feet thick, on the east, over the brickearth, which latter contained a little race, and was gravelly in parts. In the lower pit (touching the road, and not worked at the times of my visits) the brickearth is rather sandy; contains a 6-inch layer of fine gravel, and (close to the bottom) an 18 inch layer of pale Boulder Clay, with very small stones; and is underlain by a thick mass of Boulder Clay, with an irregular sandy and gravelly layer about 6 feet down. The beds rise towards the road.

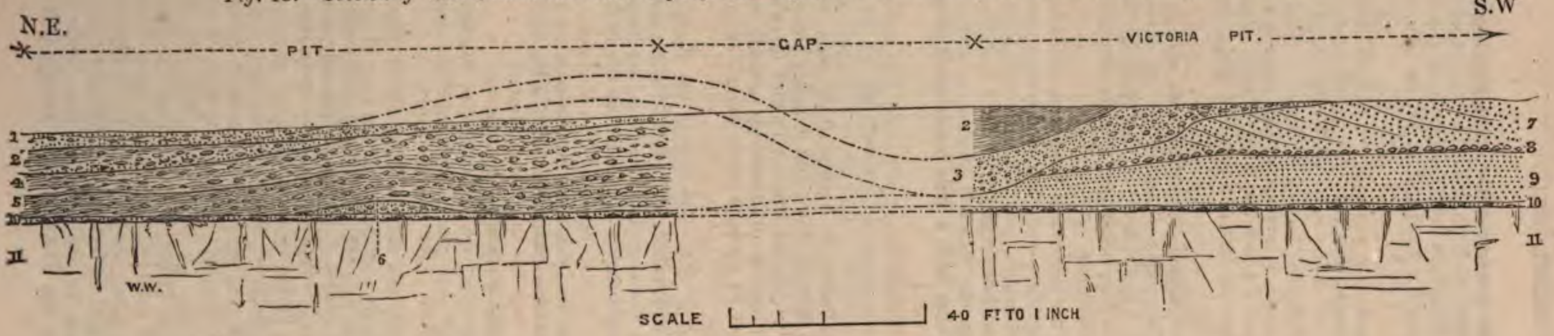
About 250 yards S.W. from this, and on the same side of the little valley, begins a set of pits, almost touching each other. The first of these is an old pit, much filled in and overgrown, but showing Boulder Clay (the lower bed) over Thanet Sand, the former spreading over to the Chalk at the N.E. part, close to the road.

Touching this is a large pit, and then, barely divided from it, another, known as the Victoria Pit. These show a sudden change in the Drift beds, the section being as in Fig. 15, p. 54.

Just above the Victoria Pit, at the edge of the town, on the top of the hill forming the S.E. side of the little valley along which the road to Waldingfield runs, a pit showed pale Boulder Clay over gravel and sand, the junction dipping sharply south-westward.

Just eastward of the large chalk-pit, the section of which is shown in Fig. 4, p. 16, is an old brickyard, but lately abandoned at the time of my visit (1873), with what may be best described as a set of pits connected together. The most southerly of these is only divided from the aforesaid chalk-pit by a footpath (parish boundary?) left on high between the two. The section is much hidden by fallen earth, but at the higher part Thanet Sand is shown, cut into by light-coloured Boulder Clay northward. The latter thickens eastward to about 15 feet and is then capped by fine sandy gravel, up to 5 feet thick, and partly cemented into stone. Above this, and often with a layer of tabular sandstone along the junction, there comes on buff and bluish-grey finely bedded loam, nearly 20 feet thick. These Drift beds, which now alone occur, dip as much as 45° north-eastward, but soon rise again in the same direction, the Boulder Clay at the base coming up along the cutting to the chalk-pit that forms the northern end of this long section, but capped tolerably evenly by the gravel and loam. At the entrance to the chalk-pit the Drift abuts against what seems to be a great pipe of the Thanet Beds; though it is very

Fig. 15.—*Section of Two Pits at the N.E. Edge of Sudbury, on the S.E. side of the Road to Waldingfield.* 1873.



1. Gravelly wash and soil (N.E. pit).

Glacial Drift.
- 2. Light-coloured brickearth.
- 2′. Pale Boulder Clay or stony brickearth ? = 2, with gravel and sand on the right ? = 3, (N.E. pit; inaccessible).
- 3. Light-coloured sand and gravel, with a patch of coarse gravel on the right (Victoria Pit).
- 4. Pale Boulder Clay (N.E. pit.)
- 5. Dark Boulder Clay (N.E. pit.)
- 6. Gravel below in parts. (N.E. pit.)

Red Crag.
- 7. Brown ferruginous sand, [? shells in bottom part].
- 8. Layer of flint-pebbles, flints, phosphatic nodules, &c.

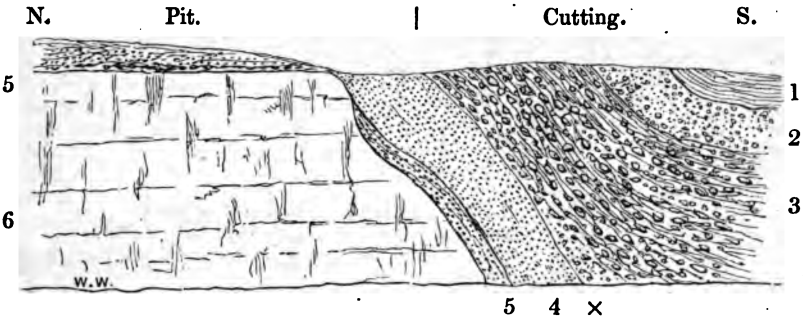
Thanet Beds.
- 9. Fine soft buff clayey sand.
- 10. Clayey greensand, with green-coated flints, 1 to 1½ feet.

11. Chalk, bedded, worked to a depth of nearly 50 feet, slight dip S.E. (into the hill).

The curved broken lines show the probable connexion of the beds.

possible that in this strange section (shown in the diagram-sketch, Fig. 16) we have evidence of a fault or slip also.

Fig. 16.—*Section on the E. Side of a Chalk-pit about half a mile E. of St. Peter's Church, Sudbury.*



Drift. { 1. Laminated brickearth.
2. Sandy gravel.
3. Boulder Clay with a little brown sand at ×.
Thanet Beds. (*See* p. 15) { 4. Fine soft sand.
5. Clayey green sand.
6. Chalk.

Touching the eastern side of the cemetery (and close to where a windmill is marked on the Ordnance Map) a new pit was being dug in 1873. At the entrance from the road, fine gravel, about 7 feet thick, occurred for about 35 yards, when pale Boulder Clay came on suddenly, abutting against (but overlying) the gravel. This ran on for over 10 yards, when it ended as suddenly against light-coloured and ferruginous sand (underlying), which was dug for another 10 yards. The pit itself had been deepened at the time of my second visit, in 1875, when it showed the following succession of beds:—

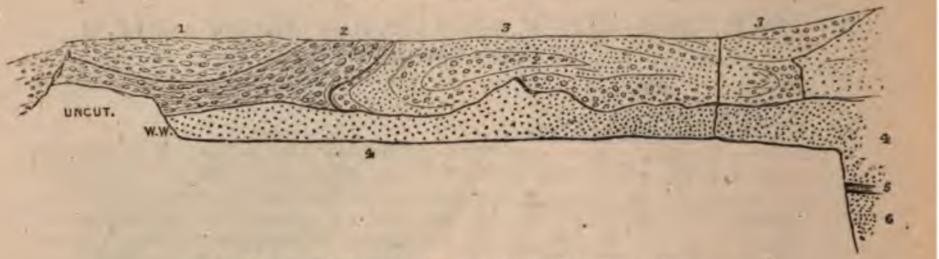
			FEET.
Drift and Crag.	Soil - - - - - - Boulder Clay - - - - - Gravel - - - - - -	about	8
	Sand, partly gravelly, false-bedded [? Crag] -	„	20
	Gravel, of phosphatic nodules and bones, flint pebbles, flints, &c. (the so-called "coprolite-bed") - - - - - -	up to	1
Thanet Beds.	Loam - - - - - - -		10
	Clayey greensand (with green-coated flints below) - - - - -	about	1

Eastward of the cemetery, and on the western side of the footpath to Chilton, a pit showed Boulder Clay filling a hollow in gravelly sand, the clearest part giving the section Fig. 17, (p. 56), looking southwards, the length of the face fronting the observer being 35 yards.

The sudden change of 3, on the right hand, from gravel to nearly all sand is remarkable. I am inclined to think that 4 belongs to the Red Crag, the line between it and 3 is sharp. At the time of my first visit (1873) I saw many phosphatic nodules lying about, but did not see the bed from whence they came. In 1875, however, the pit was deepened at one part, showing a few feet more of the ferruginous sand, and the beds below. It had been carried still deeper before this second visit, for I saw lying about some of the greensand forming the base of the Thanet Beds, and also some chalk.

Fig.—17. *Section in a Pit about three-quarters of a mile E. of St. Gregory's Church, Sudbury.*

(About 32 feet to an inch.)



Drift.
1. Pale buff Boulder Clay; up to 6 feet or more.
2. Bluish-grey and brown Boulder Clay; 5 to 8 feet.
3. Light-coloured sand and gravel, with curved bedding; up to about 10 feet.
4. Drift or Crag. Ferruginous sand (partly light-coloured at the point sticking up), false-bedded; 5 to 8 feet shown (+ 3 or 4 on the right).
5. Layer of phosphatic nodules, phosphatized bones, flint-pebbles, &c.; about 6 inches.
6. Fine soft Thanet Sand.

Turning now to the right bank of the valley of the Stour, and of its tributary from Gestingthorpe, we find that the outcrop of the beds below the Boulder Clay joins on to that of a tributary of the Colne valley, by a narrow neck from west of Wickham St. Paul to Great Maplestead.

In a sand-pit on the top of the hill, just east of the farm marked "Rectory" on the Ordnance Map, at the southern end of the village of Gestingthorpe, the following beds were seen :—

Soil, and in parts a little gravel, over a little coarse reddish-brown sand, with small quartz-pebbles.
Layer of clay, greenish-grey mottled red; about 6 inches.
Laminated light-coloured sand and pale grey clay; about 4 feet.
Fine sharp light-coloured sand the lower part light-brown; said to have been found to a thickness of 12 feet or more.

Below this clay seems to crop out, throwing out much water, and in parts it is clearly Boulder Clay, presumably the bed that often occurs in these sands, &c.

In the lower ground eastward there often occur masses of Boulder Clay, which, from the vagueness of the map and the irregularity of the beds, it was quite impossible to map separately, and which have, therefore, been included with the sands and gravels.

At the lower kiln, eastwards of the church, the chief pit, which was overgrown, seemed to be wholly in grey laminated brick-clay; but just east of the buildings the entrance to a pond (perhaps an old pit) shows this brick-clay, and, cropping up from beneath it northwards, Boulder Clay, in part so chalky as to look like chalk. More of this chalky clay occurs in the fields just north, but it is impossible to separate it from the great mass of the higher Boulder Clay, which seems to come on over it without any of the beds that usually come between.

The brick-clay was also shown in a very small pit on the northern side of the road to Bulmer, north of the kiln, and in another close to the cottage east of the kiln, where the section was as follows :—

Pockets of gravel.
Mostly a thin irregular layer of dark-brown clay, sometimes with a little gravel at the bottom, passing into the next.
Grey clay, rather sandy.

At Wisboro' Hill, a mile and a quarter S.W. of Bulmer, was a small section of light-coloured, mostly coarse, sand, with a few flints and layers of pipe-clay, just above the pit whence London Clay is got for the supply of the brickyard on the south.

Along the road down the hill northward to Bardfield Bridge, W.N.W. of Sudbury, the very shallow cutting showed the following beds:—At the top of the hill the Boulder Clay is covered by brown loam, or clay, with flints, often almost a gravel, and as the road begins to fall, the Boulder Clay occurs beneath a little brown clayey sand, which soon ends off. Then a little light-coloured gravelly sand comes up suddenly from beneath the Boulder Clay, but ends off directly, more Boulder Clay coming up beneath (as far as I could make out), or else the sand must sink under very quickly. Light-coloured sandy loam (? = the laminated brickearth) comes up from beneath this Boulder Clay, and from beneath it again another bed of Boulder Clay. Then the deeper part of the cutting was overgrown, but showed Boulder Clay and some light-coloured sand. It was simply impossible to map these divisions, and I was forced to mass all under Boulder Clay.

A pit in a field on the northern side of the hollow, about half a mile N.E. of Bulmer, gave the section below:—

Deep hollow of dark brown and grey clay with gravelly nests: at the western part.
Gravel, with many small chalk-pebbles. Very little on the N., elsewhere up to about 8 feet, and may be more on the S., where it seems to scoop into the bed below.
Pale Boulder Clay, partly with a little sand and gravel at the bottom; up to 7 feet.
Buff laminated brickearth; clear for about 15 feet, and then 6 feet or more hidden by water.

There seems to be a tendency to dip down into the hollow southward. The lowest bed here has been classed by Mr. S. V. Wood, junr., with his "Lower Glacial." *

About a third of a mile to the east, in the corner of the road, is an old overgrown pit, near the entrance of which there is fine light-coloured sharp sand; further in is coarser sand, containing a little Boulder Clay near the top at one part; and at the inner (western) end gravel, loam, and sand occur at top.

A pit on the eastern side of the high road, about a quarter of a mile south of Balingdon, showed the following beds:—

Boulder Clay; up to 6 feet.
{ Loamy and gravelly sand; up to about 5 feet.
{ Sharp sand, false-bedded, the upper part pale yellow, the lower part of a lighter colour; a little gravel between at one part; 20 feet or more shown.

An old overgrown pit on the other side of the road also shows Boulder Clay above sand.

At the northern side of the western end of the great pit south of Balingdon (*see* pp.13, 14) I saw, resting on the chalk, some gravel, sand, and loam, with a little Boulder Clay above at one spot.

At the great brickyard E. of Balingdon, known as "The Grove," the Drift comes on very suddenly on the west, abutting sharply against the Chalk and the Thanet Beds, which are well shown close by (*see* p. 13), but the sharp easterly dip soon lessens and then the beds rise in that direction. The succession of these waved divisions of the Drift in that part of the pit directly facing the stream on the north is as follows (the same figures are used for the same beds in this and other parts of the pit):—

1. Boulder Clay, in a hollow; up to 12 feet.
3. Coarse gravel; up to 10 feet or more, resting irregularly on the bed below.
4. Boulder Clay, partly pale, but darker where further from the surface; with reddish masses (probably derived from the Thanet Beds); in parts more sandy and gravelly; thick (? 20 to 30 feet).

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* *Quart. Journ. Geol. Soc.*, vol. xxxiii. p. 109 (1877).

5. Gravel and sand; hardened at top into an irregular wavy layer of calcareous sandstone, which forms a rough flooring at the western end of the pit, and dips sharply eastward.
6. A sharp ridge of Chalk, with traces of the greensand at the base of the Thanet Beds, runs along the bottom of the pit, about W.S.W. and E.N.E., that is parallel to the edge of the marsh. Except for this the Drift seems to reach the bottom of the valley.

At the time of my visits (1873, 1875) this pit turned suddenly at its E. end into the brickyard, and then there was shown a bed that did not occur in the long section just described, the succession being :—

2. Laminated stony brickearth; up to about 10 feet (apparently in a hollow).
3. Gravel and sand; 3 or 4 feet.
4. Boulder Clay.

Then the pit again turned back westward and the beds, dipping sharply northward, were :—

1. Boulder Clay, in a hollow; up to 8 feet.
2. Laminated buff brickearth; with gravelly layers, and partly separated from 1 by an irregular gravelly bed; 12 feet or more.
3. Gravel; 5–10 feet or more.
4. Boulder Clay.

The further (eastern) part of the pit is shallower and in brown gravel and sand. Just beyond is a pit in Post-Glacial gravel over Boulder Clay (*see* p. 70).

About Middleton the sand makes a marked feature, rising sharply above the London Clay.

Nearly half a mile west of Great Henny Church (about 70 yards above the road to the parsonage) the hard bed at the top of the gravel crops out from below the Boulder Clay by the side of and partly across the road.

In the same road nearly a mile westward of the church the Boulder Clay is again shown, over gravel and sand; whilst close by, just up the lane to Twinstead Green, sand alone occurs beneath the clay.

"A bed of Boulder Clay occurs in the gravel north of Alphamstone, and is traceable for more than half a mile."*

W. W.

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* From Mr. Dalton's Notes.

CHAPTER 9.—GLACIAL DRIFT (*continued*).

BOULDER CLAY.

Over a very large part of the area mapped in sheet 47 there occurs a deposit of grey clay, so persistent within that area (and far beyond it) that at a glance it is evident the clay was not formed in fragments as mapped, but in one continuous sheet. It has been cut through in post-glacial times by the present valleys, but with this exception it spreads over high and low ground alike, being found from the top of the Chalk escarpment down to points not greatly above the level of the sea.

The clay rarely presents any signs of stratification; it encloses many large and small, worn and unworn, fragments of various rocks, sometimes as scratched and rounded pebbles, at others masses, even of the softer deposits, are included. The main substance of the clay indeed consists of material derived from rocks at no great distance from the point where it may be observed; in this district it is very chalky.

In deep cuttings and in wells the clay is found to be dark grey, but nearer the surface it is always of a lighter colour, sometimes nearly white, from the effects of weathering. It is never of great thickness, that is, compared with many of the older clays; in this district it does not exceed (so far as hitherto observed) 140 feet (?). There are beds of sand and gravel intercalated with the clay, but these are exceptional and never of any great extent or thickness. Its lower part is sometimes sandy, but as a rule it rests directly and evenly (except when viewed on a large scale) upon the beds beneath.

W. H. P.

Some parts of the Boulder Clay consist almost entirely of chalk. Where it lies directly upon the London Clay it is often mainly composed of the latter, being a blackish or reddish-brown clay with a few pieces of chalk and other rocks. The bottom-bed varies from 4 to 40 feet in thickness, and contains thin beds of sand and gravel, and water is frequently obtained at its junction both with the London Clay below and the white chalky Boulder Clay above. The interbedded seams of sand and gravel vary from a few inches to several feet in thickness.

Boulder Clay has been much dug for dressing the land, but has fallen into disuse since the establishment of railways, chalk being found to be more efficacious, as five loads of the latter to the acre serve the purpose of 20 of the Boulder Clay. The inferiority of the Boulder Clay is due partly to the clayey matrix enveloping the chalk-pebbles, but chiefly to the greater hardness of those pebbles, which enables them to resist the dissolving power of water in the same measure that they resisted the grinding of the glacial action.

W. H. D.

At the base of the Boulder Clay, where it rests on the Chalk,* there frequently occurs a hard light-grey crystalline bed 3 or 4 inches thick. It is mostly seen where the clay occupies an old hollow, and was formed evidently after the deposition of the clay, probably after the last elevation of the land. It has been suggested that the band has resulted from the percolation through the clay of water, which in its passage has removed, as a bi-carbonate, part of the carbonate of lime the clay contains as chalk boulders, and re-deposited this at its base in the crystalline form in which it is now found. Many similar beds are doubtless formed in this way, but as regards the one in question this cannot be accepted as the true explanation. The clay is almost, if not quite, impervious, while the Chalk below is especially permeable; and I incline to the belief that the carbonated water has passed down through the Chalk, become super-saturated with bi-carbonate in its passage, and thrown down the excess where it pressed in every direction against the underside of the impervious Boulder Clay. This view is strengthened by a similar deposit having been noticed as partly lining the interior of a large pipe in the Chalk, filled, where the deposition was taking place, with dark brown impervious clay. The hardened wall is nearly vertical; and the crystalline band passes outwards into soft and earthy chalk, while inwards it ends abruptly against the clay, which has no trace of lime in its composition.

This hard bed may be seen in many sections, a few of the most noteworthy being in the following chalk-pits:—Half a mile S.S.E. of Wenden Lofts (*see* p. 11), N. of Little Chishall Church (p. 10), a mile south of Bartlow Station (p. 41), a mile N. of Reed (p. 12), and in the railway-cutting W. of Dullingham Station (just in sheet 51, S.E.).

In some few instances small deposits of gravel are found, which can be referred neither to the series below the Boulder Clay nor to the plateau-gravels above it. They occur within the mass of the clay, which is occasionally to be seen above and below them, although generally they are found as patches on a flank, the overlying part of the clay having been eroded.

A good example may be seen at Hood End, on the "Suffolk Way," between Finchingfield and Stambourne.

At a pit W. of Hood End, chalky gravel, with patches of light-coloured sand (4 or 5 feet), seems to rest on the Boulder Clay.

In the pond at Hood End there is again chalky gravel over Boulder Clay; and in a pit half a mile N.E. of Hood End, 4 feet of gravelly loam occurs, like some seen in a ditch resting on Boulder Clay.

Another pit half a mile N. of Hood End gives the following section:—

	FEET.
Boulder Clay - - - - -	2
Gravel (irregular) - - - -	2
Grey loamy sand.	

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* A like hardened layer sometimes occurs at the top of the gravel or sand that underlies the Boulder Clay, as noticed in some of the sections described in the foregoing chapters.—W. W.

This section gives a key to the others, as it shows Boulder Clay over the gravel, which therefore is a bed within the mass of the clay.

The small exposure of fine chalky gravel in a gully at Stambourne Green is probably in the same position.

In a new ditch, about three furlongs E. of Little Yeldham Church, a similar bed of gravel, about 4 feet thick, was exposed, with the clay both above and below. It thins away rapidly, but a small patch occupies the surface on the opposite side of the valley, between Little Yeldham and North End, and traces occur, with clay above and below, at The Fowes, a mile N.E.

Sections of the Boulder Clay are plentiful, from the many pits formerly made to get the clay for the above-mentioned purpose. It is laid open to a considerable depth in some of the railway-cuttings.

"I was told that a depth of 12 feet of Boulder Clay was found in making the gas-holder at Haileybury College in 1867."

"About a third of a mile N.E. of Elmdon church (5 miles westward of Saffron Walden) the ending off of the Boulder Clay is shown in a chalk-pit where there is a hollow filled with the clay."*

A new well at the eastern end of Wicken Bonnett passed through 5 feet of Boulder Clay and 25 feet of chalk, and a pit, half a mile E. of the village, shows 6 feet of Boulder Clay on Chalk with flints.

The railway-cutting on the Saffron Walden branch by Newnham Hall, S. of Bartlow, shows Boulder Clay with a knob of chalk rising up from beneath and a lenticular patch of gravel and loam in the mass of the clay.

The railway-cutting on the Cambridge and Sudbury branch at Horseheath Green, three miles westward of Haverhill, gives a good section, 45 feet deep in grey Boulder Clay, which contains some large boulders of chalk, sandstone, &c. A well made here by the contractors showed the thickness of the clay to be 120 feet.

From information supplied by well-sinkers the thickness of the Boulder Clay on the higher ground, about Thaxted, would be as under:—Elms Farm, two miles N.N.W. of the town, 100 feet; at Bardfield Green, a mile E. of the town, 120 feet; whilst at Tindon End and at Cutler's Green it is 140 and 80 feet respectively.

W. H. P.

Many junction-sections with the underlying gravel and sand have been already described; some others along the valleys in the S.E. part of the district may now be noticed.

Cann Valley.—At Chalk End a well passed through 12 feet of whitish clay and 36 of blue clay, to London Clay; and at Dyer's Hall, near and E.S.E. of Chignall Smeeley Church, 16 feet of whitish clay and 24 of blue clay were found above sand.

Chelmer Valley.—At Hyde Farm, over a mile and a half N. of Little Waltham, 19 feet of whitish clay and 35 of blue clay were found in a well above 6 inches of gravel (? to London Clay).

The patches of Boulder Clay at the edge of the map near the Cock Inn (wrongly named "Clock House") between the Chelmer and Ter Valleys, seem to pass under the gravel on the north and to join on to the larger mass by the railway.

Ter Valley.—At Pond Park, 8 feet of whitish and 20 of dark Boulder Clay were found over sand and gravel in a well. At the Dog and Partridge, Chatley Hamlet, 16 feet of Boulder Clay occurred above gravel and sand, pierced to the same depth.

At Great Leighs Parsonage the junction can be made out, though not clearly, in an old pit, and may also be seen in road-cuttings S. and S.E., the base of the clay dipping southward.

Above Fairsted the junction is obscured by a deep loam, apparently a rain-wash from the clay on the east. At Troys Hall, on the east, a well pierced 60 feet of Boulder Clay.

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* From Mr. W. WHITAKER'S Notes.

In a pit N.E. of the road, at the farm a mile S.W. of Terling, the base of the Boulder Clay was seen to be conformable to the bedding of the sand beneath.

Between Great Farsley and Leithfield Farms, S.E. of Terling, the junction is shown in a road-cutting; and in a large old pit, about a third of a mile S.W. of Tormings Farm (opposite the entrance to the farm), the Boulder Clay wraps round a boss of gravel.

Guith Valley.—The junction with the underlying beds was seen on the railway near Bulford Station, near Hungry Hall, and in the gully opposite Faulkbourn.

Blackwater Valley.—In a pit at Withers Green, E. of Braintree, Boulder Clay, about 12 feet thick, was seen over gravel and sand.

At Capons, a mile and a half W.S.W. of Coggeshall, a well passed through 30 feet of Boulder Clay and 25 of sand and gravel.

At the brickyard N.W. of Coggeshall the beds shown are:—

Loam; 6 feet at least, with a sprinkling of gravel at bottom.
Boulder Clay. { White chalky clay, 3 feet.
Dark blue clay, with rounded, polished, striated blocks of granite, Lias limestone, and large slabs of Oolitic shale, crowded with fossils.
London Clay.

Half a mile N.E. of Feering the public well at the fork of the roads passes through 15 feet of Boulder Clay to water.

Half a mile N. by E. of Priested Hall an old pit reaches to sand through about 16 feet of Boulder Clay.

The "Clay Pit," marked on the Ordnance map, between Feering and Inworth, is a brickyard, worked in Boulder Clay (the upper part whitish, the lower dark blue) to a depth of at least 30 feet. It is then not bottomed, and therefore the base must be some depth below the river, and the clay is probably continuous across the valley to Kelvedon, as at Witham, though overlaid by Valley Gravel in both cases. Between Feering and Witham, indeed, the Boulder Clay sinks down, cutting out the underlying Glacial gravel, and resting on the London Clay, as shown in Fig. 19, p. 69.

Small inliers occur in the tract of Valley Gravel: one near Coleman's Farm, another at the rifle-butts below Little Braxted Mill.

The Boulder Clay does not occur either on or S.E. of the range of Tiptree Heath, and this ridge would seem to have been the limit of deposition of that bed. Well-sections in a line from Braintree by Witham to Heybridge and Northey, in the estuary of the Blackwater, just outside our district, prove that there is an undulation of the Chalk and the overlying beds between Witham and Heybridge. Possibly the line of disturbance thus shown may trend in the direction of the ridge of Tiptree Heath, and have had some share in its production. The south-westerly extension of this line would be towards the Bagshot outliers south of Chelmsford (in Sheet 1, N.E.)

W. H. D.

Mr. John Brown, of Stanway, has described the section of Boulder Clay in the cutting on the high road at Balingdon Hill, S.W. of Sudbury, made in 1835, and noted the varieties of rocks and derived fossils found in it.*

It will be convenient to notice here a strong loam or clay that often occurs as a thin capping on the Boulder Clay, from the gradual decomposition of which indeed it seems to have originated.

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* *Mag. Nat. Hist.*, vol. ix. pp. 42–44 (1836).

The lumps of chalk seem to have been dissolved out, whilst the insoluble flints, &c. have been left behind, and the colour has changed to a yellowish brown. It is difficult to separate this stony loam from the Boulder Clay on the map, and though an approximate boundary-line has been drawn, the loam is not distinguished by colour, but only by the engraved word "Loam."

This deposit would seem to be analogous to the "clay-with-flints" that so generally occurs over the Chalk in Berks, Bucks, Kent, &c.*

W. W.

About half a mile eastward of Beazley End, north of Braintree, by the road to Gosfield Hall, a brickyard showed a thickness of 4 feet of loam over Boulder Clay.

On the western side of the road from Braintree to Halstead, about half a mile before reaching Trotters Green, is a brickyard, the pit in which showed stony loamy clay, about 5 feet thick, resting irregularly on and passing into very chalky Boulder Clay, which also was dug to a depth of 5 feet.

About a mile and a half N.E., in Rayne Hatch Wood, is another brickyard in the same loam with flints, 4 feet deep.

At Southey Green, S. of Sible Hedingham, a brickyard shows 5 or 6 feet of brown clay with large unworn flints (the top part is the most stony) over dark Boulder Clay. At one part the earth is less stony and more loamy.

At a pit, marked on the Ordnance Map, just N. of the 45th milestone at Gosfield, brown stony loam, 8 feet thick, caps the Boulder Clay.

About a mile out of Halstead on the road to Little Maplestead was a section showing 7 feet of loam.

F. J. B.

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* See *Memoir on Sheet 7 of the Geological Survey Map*, p. 63, 1864, and *Guide to the Geology of London*, 1875.

CHAPTER 10.—POST-GLACIAL DRIFTS.

VARIOUS LOAMS AND GRAVELS.

Here and there on the hills and higher grounds are patches of loam and loamy gravel, never of any great extent or thickness, but forming portions of what once was probably a much larger extension. The fragments now left generally occupy slight depressions in the Boulder Clay or other bed on which they occur, and seem to pass down into it without any definite line of division. They occur at nearly all levels from the top of the Chalk escarpment down to the higher terraces of the present valley system.

[It is possible that some of these loams may be allied to the stony loam just described.—W. W.]

At the kiln on the top of the Chalk escarpment, half a mile N. of Reed is a small patch of brown brickearth 6 feet thick, over Boulder Clay.

In a pit N.E. of Cocken Hatch, Barkway, 6 feet of coarse chalky gravel were shown above Boulder Clay.

At the brickyard at Morrice Green, 2 miles E. of Barkway, mottled loam occurs to a thickness of 5 feet.

At the brickyard on the eastern side of Rickling Green, Quendon, 10 or 12 feet of sandy brickearth is worked.

There is a small patch of loam over Boulder Clay, on Windmill Hill, N.W. of Saffron Walden, in which was found, 3 feet from the surface, a beautifully-chipped flint spear-head, now in Mr. Tuke's possession.

At the brickyard on Bedwell Green, Great Hallingbury, there is a small patch of brown sandy loam, forming the higher ground and filling a hollow in the Boulder Clay. The loam is 8 feet thick in the centre and thins out in every direction.

At Hatfield Heath several small pits show gravel, 2 or 3 feet thick, over Red Loam, over Boulder Clay.

At Matching Green other small pits show 2 or 3 feet of loamy gravel over Boulder Clay.

A pit on high ground W. of Ashen Church, S.W. of Clare, showed 6 feet of angular gravel in a brownish sandy matrix, apparently over Boulder Clay.

In a gravel-pit half a mile W. of Clare (just S. of the pit in Glacial Drift, *see* p. 49), there was chalky gravel with sand below; 4 feet, over Boulder Clay.

These plateau-deposits, or rather remnants of them, occur, as gravels or loam, N. of Thaxted, at Finchingfield, Belchamp St. Paul, and near Braintree.

There are also many pipes of loam and sand in the Boulder Clay, indicating a former extension of these Post-glacial deposits; for instance the railway-cutting S.E. of Birdbrook Station shows some pipes of clean, yellow sand, there being no bed of sand now at a corresponding height in the neighbourhood.

W. H. P.

There are patches of loam on the higher ground on either side of the Ter. One of these is continuous from south of Chantry Hall, northwards, nearly to Terling.

At the brickyard between the high road and the railway, east of the 34th mile-post, there was shown fine brown loam, 14 or 15 feet thick, the lower part stony, on Boulder Clay; and in the railway-cutting further eastward, there is a thickness of 8 feet of the former on Glacial gravel. A pit in another brickyard, at Hatfield Wick, was 10 feet deep, in brown brickearth over finely laminated grey and buff loam (1872). At Terling Hall the loam was seen to rest on Boulder Clay.

There are two other masses of loam north and west of the above.

North of Coblers Green, Felsted, loam, overlying Boulder Clay, has been worked for bricks.

From Bannisters Green to Cock Green, a strip of loam occurs, associated with gravel on the north. At Willows Green is another patch.

At Gobion Green is a large mass of loam, with seams of gravel, and with peculiar nodules of carbonate of lime, south of Paul's Wood. This is seen to overlie the Boulder Clay at its western edge by Bishops Lees.

W. H. D.

" At Ark Farm, three-quarters of a mile N.W. of Cavendish, there is a patch of angular flint gravel with a few pebbles of quartz, and at the corner of the road about 10 chains south, there is a smaller patch; both appear to overlie the Boulder Clay."

" About half a mile S.E. of Ark Farm are two small patches of gravel on the edge of the Boulder Clay, neither apparently of much thickness."[*]

OLD RIVER GRAVEL AND BRICKEARTH.

The Valley loams and gravels are not extensive, and it is probable that some of the deposits that are really more recent have been included in the mapping with the Glacial gravels which occupy most of the valleys, and from which they cannot readily be separated. There are some deposits, however, which can be identified as of more recent origin than the Glacial Drift, as at the head of the Stort valley, in the valley of the Blackwater, near Witham, in various parts of the Stour valley, along the Cam valley, and in the N.W. corner of the sheet.

In a few instances land and fresh-water shells are found in the loams, while some of the gravels contain the bones and teeth of mammalia with an occasional flint implement. W. H. P.

Valley of the Lea.

Hertford is chiefly built on a flat of river-gravel. Mr. Docwra tells me that the well at Christ's Hospital passed through 16 feet of gravel to the Chalk. At Ware and north of Amwell are other like flats, bordering the river, and from St. Margaret's southwards, a much broader sheet, on an island of which Rye House is placed. W. W.

Valley of the Quin.

The pit at the brickyard a mile S.E. of Barkway gave the following section, all the beds lying unevenly, and in one part 3 feet of gravel overlying the loam.

		N. end.	S. end.
		FEET.	FEET.
Post-Glacial Drift.	Brown mottled clay	—	3 to 4
	Light grey clay	—	1
	Brown sandy loam	2	3 to 4
	Yellow and ironstained loam	—	¼
	Grey loam	—	1
Boulder Clay		6	
Soft chalk		1	
		9	9¼

W. H. P.

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[*] From Mr. C. E. Hawkins' Notes.

In a gravel-pit between the high road and the stream, about a mile north of Hare Street, there is, at about 7 feet below the surface, a layer of grey bedded loam with a few broken pieces of shells (*Bythinia?*)

W. W.

Valley of the Stort.

A pit in the village of Clavering showed 10 feet of gravel with patches of loam containing shells of *Bythinia* and *Pupa*.

At the tile-kiln N.E. of Harlow Station the following beds were seen:—

		Feet
Post-Glacial Drift.	Brickearth - - - -	8
	Yellow sand - - - -	2
	Chalky gravel - - -	5
Glacial Drift.	Chalky loam, not bottomed - -	4

The Post-Glacial beds dip irregularly towards the valley and seem to thin out in that direction. Bones and teeth are found between the gravel and the loam.

W. H. P.

Valley of the Chelmer.

At Chignall Smeeley, in a tributary valley, a brickyard is worked in a deep loam, which seems to be a wash of the Boulder Clay. Near the church a well passed through 7 feet of sandy loam and 9 feet of wet sand to Boulder Clay.

The gravel at the Cock Inn (miscalled "Clock House" on the Ordnance Map), on the high road W. of Hatfield Peverel, overlies the Boulder Clay and passes under the loam to the east.

Ter Valley.

On the right bank of the stream, near Hatfield Peverel, a brickyard showed loam, the uppermost 8 feet being a fine yellowish-brown earth, and the lower part more clayey and not used.

W. H. D.

Valley of the Guith.

On the southern side of the high road, about a mile westward of Braintree Church, is an old pit, almost hidden, in which Mr. Penning and myself found laminated clay and loam, with broken shells, the bed being of the same character as that in the valley of the Blackwater (*see* p. 67).

W. W.

At the forked roads, a quarter of a mile S. of Braintree Goods Station, a brickyard-pit showed, in 1872, 16–18 feet of fine grey and buff loam resting on a thin bed of sandy gravel, in a broad shallow hollow of the London Clay, which last came up near the western road, and was said to have been found east of the other road.

At the brickyard just east of Warren Farm, Faulkbourn, the northernmost pit, within the park-fence, laid open (in 1872) about 8 feet of bedded brick-earth, in part clayey, light-brown, grey at the bottom, below which gravel was said to have been found. Another pit, nearest the farm-buildings, showed 3 or 4 feet of loam on gravel; and a third, near the river, showed a little gravel resting irregularly on brown London Clay.

W. H. D.

Valley of the Blackwater.

On the western side of the lane N. of Petches Bridge, W. of Wethersfield, a pit showed about 8 feet of rather coarse sub-angular gravel, with a bed of sand near the bottom. In this sand I found a small piece probably of the tusk of an elephant, a small molar of the same, and a few rib-bones of some small animal. At another part of the pit I found a fragment of a larger elephant-molar. Large bones are said to have been found in digging for foundations at Daw Street on the N W.

F. J. B.

From Feering to Witham occurs the chief mass of River Drift in this valley; it consists of gravel, loam, and shell-marl, not separable on a small scale. The lower masses are mostly gravel.

A small pit 200 yards S.S.E. of Feering Mill goes through the gravel to Boulder Clay and the underlying sand.

In the railway-cutting at Feering the gravel forms the bank on both sides, but the permanent way probably rests on Boulder Clay throughout the cutting; this is certainly the case at the western end.

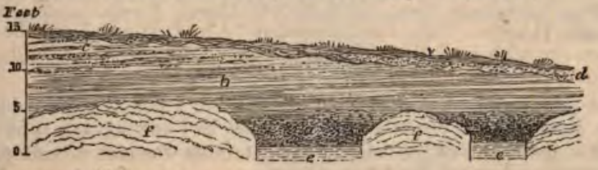
Between Feering and Kelvedon the gravel has been denuded in such a way that the Boulder Clay is exposed as a narrow belt skirting the brow of the hill.

Opposite Kelvedon church a thickness of 24 feet of gravel has been found over Boulder Clay in a well, and the railway-cutting between the church and the station goes through a boss of Boulder Clay under the gravel.

W. H. D.

The brickyard at Appleford Bridge had been abandoned before the Geological Survey of this district was made, but luckily a drawing of the section had been taken by Mr. S. V. Wood, jun., which we are enabled to reproduce, through the kindness of the Council of the Geological Society, with some additional details from Mr. Wood.

Fig. 18.—*Section at Appleford Bridge, N.E. of Witham.* (S. V. Wood, jun., *Quart. Journ. Geol. Soc.*, vol. xxxiii., p. 111, 1877.)



e. Water. *f.* Talus, etc.
d. Gravelly wash and soil.
Post-Glacial. { *c.* Red sandy gravel, passing down into fine-bedded yellow sand, more loamy downwards, and passing into *b.*
b. Sandy bedded brickearth, passing down into *a.*
a. Blue Boulder Clay, with chalk-pebbles.

W. W.

From Hole Farm, S.W. of Kelvedon, to Chipping Hill and Witham, shell-marl occurs and comes to the surface at intervals.

This marl has been proved, in a well at Durward's Hall, under 5 feet of sand.

At Rivenhall End, at the back of the Workman's Hall, is a reservoir-well fed by a spring from near Hoo Hall. The conduit-trench showed (1872) a mixture of sandy, gravelly, and loamy deposits, with a layer of marl and another of peat, the irregularity of which beds may be seen from the following details:—At the northern end, after crossing the peaty alluvium of the brook, the trench was in gravel, mostly coarse, with patches of sand, and with a bed of marl about a foot thick and dipping sharply (10°–15°) to the S.E. The marl descending with the dip reappeared again for a short length nearly horizontal, and then sank again, stiff clay appearing under the gravel. 3 feet or more above this clay was a lenticular mass of peat, 1½ feet thick, covered with coarse gravel and loam, which passed southwards into sand at 200 yards from the edge of the alluvium. This sand extended downwards to about 2½ feet below the level of the brook, resting upon the shell-marl, into the mass of which the reservoir-well was carried to 20 feet (making in all 40 feet from the surface) without penetrating it. The earth thrown out from the bottom of the well was pale and laminated. From the *débris* were collected (by Mr. Whitaker and myself) shells of *Bythinia tentaculata*, Linn, *Helix* (?), *Limnæa* (?), *Succinea*, *Valvata piscinalis*, Müll. and *Pisidium*, and vertebræ of fish.

Marl also occurs on the main road at Rivenhall End and on the lane to Great Braxted. On the main road east of Burrell's Barn the marl rests slightly unconformably on sand and gravel, with a 2-feet seam of loam containing laminæ of marl. Between this and Witham the marl is exposed or has been proved in many places.

The Rev. O. Fisher tells me that he got a flint implement from the gravel at Witham Station.

South of the station, a well in a brickyard, used in 1847, passed through gravel (below the brickearth), 15 feet; shell marl, 15 feet, and running sand, 4 feet.

About 200 yards east of the church at Chipping Hill the gravel is about 10 feet thick, and wells sunk through it, and the marl reach the sand at 20 feet deep. At the Woolpack Inn, north of the church, the marl is absent. In the High Street, Witham, the shell-marl was found in making the sewer.

The section, Fig. 19, illustrates the structure of this part of the valley, as hown by wells.

On the northern side of Braxted Park gravel and sand overlie the Boulder Clay. The gravel forms steep banks on either side of the artificial lake (in London Clay), whilst Boulder Clay occurs below the dam.

On the western side of the road N. of West Hall, Little Braxted, sand, 5 feet thick, overlies Boulder Clay.

W. H. D.

The following list of gasteropods from the Post-Glacial beds at Witham is from a manuscript list by the late Dr. S. P. Woodward, for which I am indebted to his son Mr. H. B. Woodward. The shells were collected by the late Mr. John Brown, probably from the shell-marl described above :—*Carychium minimum*, Müll., *Clausilia rugosa*, Drap. (=*C. nigricans*), *Limnæa truncatula*, Müll., *Pupa marginata*, Drap., *P. palustris*, Leach, *Vertigo pusilla*, Müll., and *V. pygmæa*, Drap.

Valley of the Colne.

At the brickyard just west of Yeldham Station I saw the following section, with Mr. Bennett, who remarks that the bones had been mostly split open (? for the sake of their marrow) and that amongst them was part of a deer's horn :—

Brickearth and gravel, up to 8 or 9 feet.
Lighter-coloured brickearth, with bones, 2 feet.
Black sandy peaty earth, with land and fresh-water shells, said to be 6 feet.

W. W.

Valley of the Stour.

At the brickyard S. of Kedington there is sandy loam 10 feet deep, below which gravel is said to occur.

A pit a mile N.W. of Haverhill showed 6 feet of chalky gravel with patches of sand and loam containing shells (*Bythinia, Limnæa, Succinea*).

At the brickyard just S. of the above was the following section :—

	FEET.
Fine gravel and sand false-bedded eastward	5
Grey loam with bones, &c. said to be found in its lower part	4

An old pit by the old Colne Valley Railway Station a quarter of a mile S. of Haverhill Church gives the following section :—

		FEET.
Post-Glacial Beds, passing one into another.	Brown gravelly sand	3
	Fine sandy gravel	3
	Brown sandy loam with thin gravelly patches	7
	Gravelly loam	1
Glacial Drift.	Grey loam and sand in irregular masses, resembling Reading Beds resorted.	

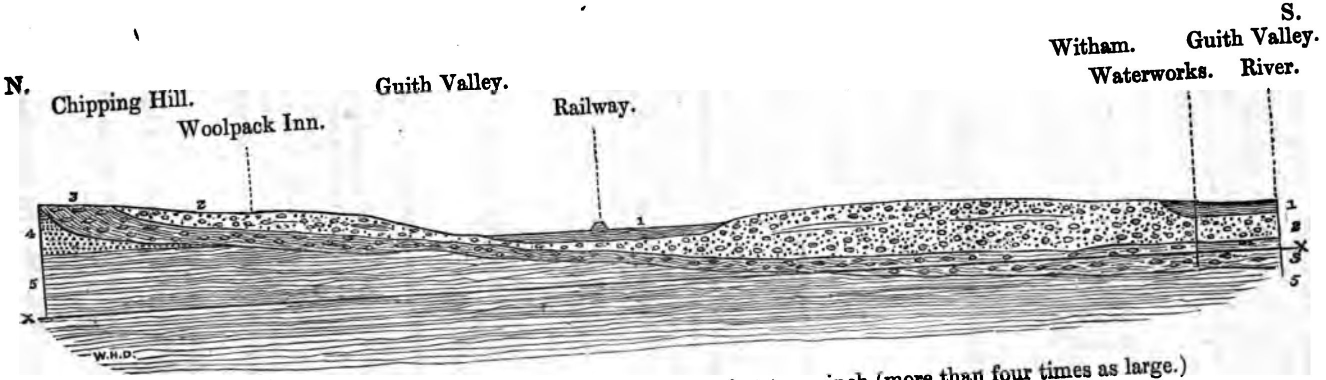
Just N. of Brook Hall, Borley, is a brickyard in loam.

W. H. P.

At Long Melford it is difficult to divide this gravel from that of Glacial age.

The railway-cutting just west of Brundon Hall, N.W. of Sudbury, has been in part cut back, for ballast, on the western and higher side, between the two bridges over, and though much hidden by talus, an interesting section is shown. At the southern end gravel and sand with loam may be seen, and beneath, at

Fig. 19.—***Section at Witham.***



Horizontal scale, 6 inches to a mile; vertical scale, 200 feet to an inch (more than four times as large.)

× Ordnance Datum.
1. Alluvium.
2. Post Glacial Drift (gravel, sand, shell-marl, and brickearth).
Glacial Drift { 3. Boulder Clay.
Glacial Drift { 4. Sand and gravel.
5. London Clay.

Valley of the Bourn.

A pit S. of Ashdon Church showed 8 feet of rough gravel, rather chalky at top, and with a black band near the bottom.

At the brickyard three-quarters of a mile S. of Bartlow Station there is brown sandy brickearth, dipping towards the valley (E.), 10 feet thick.

In the Saffron Walden Museum there are two tusks of *Elephas primigenius* from here. At a pit just S.E. of the above there is gravel, 5 feet thick, with shells of *Bythinia*, *Helix*, and *Pupa*.

The large pit just W. of Bartlow Station shows 40 feet of fine chalky gravel, ironstained and in pipes at the top, with many thin bands of sand and loam in the central part, then a dark line (? manganese) and chalky gravel below. All the bands dip S.S.W. 15°. Two other smaller pits near by show the same features. (This gravel is of doubtful age.)

The Valley Gravel close by Bartlow Station contains shells of *Limnæa*, *Pupa*, and *Succinea*.

A small pit, by Barham Hall, eastward of Linton, was 6 feet deep in gravel with a thin patch of loam, containing shells (*Pupa*).

In addition to the Post-Glacial gravels, shown as such on the map, there are many patches of Valley-gravel and brickearth, unimportant in extent and thickness, that could not be definitely divided from the Glacial beds in which most of the valleys are cut out. These are banked against the denuded Glacial gravels, and consist mainly of material therefrom re-arranged and generally with signs of bedding. The following are some of the instances in which these gravels are exposed:—

A pit on the W. side of the Stort, near Pesterford Bridge (Stansted), was 10 feet deep in angular gravel, with a few pebbles (very few being quartz) in a sandy matrix, ironstained in places.

A pit a quarter of a mile S.S.W. of Tednam Mill, Little Hallingbury, was 12 feet deep in sub-angular ironstained gravel, with patches of sand.

Another pit, S. of the church at Bocking, showed 17 feet of sandy gravel, from which a tooth of *Elephas primigenius* has been taken.

W. H. P.

ALLUVIUM.

Although most of the streams are bordered by a flat strip of this, their newest deposit, there are no large spreads of it, the greatest being where the Stort flows into the Lea.

The alluvium consists for the most part of a brown mud or silt, peat or peaty earth occurring also; sections are rare, except along the courses of the streams, but the following account of one in the valley of the Cam has been preserved by the late Mr. G. E. Roberts,* and is of interest from the number of bones found.

"In the course of railway works between Audley End and Saffron Walden, it became necessary to divert the course of the River Cam into a part of the meadow land bounding the stream, which was traditionally known as 'the old river bed.' A cutting about 20 feet deep through this, necessitated for the foundation of a wide and large culvert to give passage to the river through the railway embankment, disclosed the following section":—

		Feet.
Soil		1
[Alluvium.]	Clay	3
	Peat. Bones at the bottom	12
Gravel.		

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* *Anthropological Review*, vol. ii. pp. lxi–lxiii (1864).

"Near the bottom of this 'peat,' and at a depth from the surface of 16 feet, an astonishing quantity of mammalian bones were found . . . . out of the excavation—an area of not more than 20 feet by 60—two cart-loads of '*large bones*' were taken away."

"The peat is, more properly, a blackish clay, with numerous fragments of wood and a few logs of considerable size bedded in it. It is everywhere full of fluviatile shells of species common to the district, and contains many naturally-formed chips and flakes of flint, and a few rolled pebbles."

"The bones, which bear artifically-made markings,* are the lower jaws of a small ox, probably *Bos longifrons*."

"A single tooth of badger (?) was found at the same level in the cutting."

"A remarkably fine horn of the great elk, *Cervus Megaceros*, was also found in association with these bones."

In a side-valley on the western side of the high road, and about half a mile S.W. of Audley End House, a brickyard was worked, in 1876, in brown alluvial clay, to a depth of 4 feet.

Mr. Dalton notes that where the Rivenhall Brook passes under the railway N.E. of Witham, the alluvium consists in part of alternate beds of peat and calcareous tufa, full of shells; and that similar tufaceous deposits occur in the neighbourhood at swampy spots on the shell-marl (p. 67) and on Boulder Clay.

W. W.

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* Made by implements of flint.

APPENDIX 1.—WELL-SECTIONS.

For previously published well-sections at Bocking, Braintree, Halstead, Saffron Walden, Witham, Amwell, Berry Green (Hadham), Bishop's Stortford, and Haileybury, see Memoirs of the Geological Survey, Vol. IV., pp. 430, 431, 436, 440, 445, 447, 449–451, 453 (1872).

CAMBRIDGESHIRE.

Bassingbourn.—Coprolite Works, E. of Bleak Hall.

Water overflows.

	Feet.
Gault, with a layer of phosphatic nodules near the bottom, about	115
Sand	3
" Rock," hard, had to be punched through.	
About	120

Bassingbourn.—Communicated by Mr. N. W. Johnson.

Blue clay [Gault] to rock, about 150 feet.

Castle Camps.

Information from Mr. G. Ingold.

Shaft 140 feet, bore 64 feet. 10 feet of water in shaft.

	Feet.
To Chalk	40
In Chalk	164
	204

Castle Camps.

Shaft 154 feet, the rest bored.

	Feet.
Gravel	7
Clay	13
Chalk	164
	184

Royston.—Waterworks, near the Railway Station.

A good spring of water stands 23 feet down.

Clunch [Lower Chalk] rather more than 100 feet, with a hard rock (8 or 10 feet thick) 40 feet down.

ESSEX.

Braintree.—(Mr. Brown's.)

Trial-bore, made and communicated by Mr. Brown.

		Feet.
[Drift, 14 ft.]	Sandy gravel	5
	Drift clay	9
[London Clay, 126 ft.]	London Clay	56
	Vein of sand, with a little water	—
	London Clay, sand and shells	40
	Cement-stone	1
	London Clay, and sand	29

[Reading Beds 55 ft.]	Dark sand, with water		10
	Mottled clays		45
Light-coloured [Thanet?] sand			33
		To Chalk	8
Chalk			17
			245

BULMER.—Armsea, about a mile S.W. of Sudbury.

Sunk and communicated by Mr. COOPER (of Halstead).

Shaft 96 feet, the rest bored.

		Feet.
Chalky clay [Boulder Clay?]		30
Sand, greenish at bottom		25
	To Chalk	55
Chalk	about	195
		250

COGGESHALL.—Swinburn's Isinglass Factory.

Information from Mr. J. HATLEY, well-sinker.

Shaft 35 feet, the rest bored. Water rose to 14 feet below the ground.

			Feet.
Soil		about	2
[London Clay?]	Yellow clay	„	18
	Blue clay	„	130
	Sand (spring)	„	5
	Brown clay	„	20
[Reading Beds.]	Sand (spring)	„	8
	Mottled grey clay	„	10
	Greenish sand	„	20
[Thanet Sand.]	Slate-coloured loam	„	30
	Flint-gravel	„	1
	To Chalk	„	244
Chalk		„	16
			260

COGGESHALL.—Mr. Gardner's brewery.

Information from Mr. J. HATLEY.

Water overflowed. 100 gallons an hour.

	Feet.
Gravel	25
London Clay	120
Slate-coloured sand	60
To green sand	205

COLNE ENGAINE.—Mill.

Information from Mr. J. HATLEY.

Through clay to sand, 60 feet.

EARL'S COLNE.—Atlas Ironworks.

From specimens at the office, and from information given there and by Mr. PURKISS (well-sinker).

Shaft 85 (or 100) feet, the rest bored.

Water rises to a height of 80 feet below the surface. Supply abundant; 600 gallons an hour.

		Feet.
Gravel		14
[London Clay]	Stiff Clay to a depth of 100 feet Then loam [sandy clay] Brown sandy clay at 170 feet (specimen)	176 ?
[Lower London Tertiaries].	Green red-mottled sandy clay at 190 feet (specimen) Green brown-mottled sandy clay at 200 feet (specimen) Red and green-mottled sandy clay at 210 feet (specimen) Buff clayey [? Thanet] sand at 250 feet	105 ? (or 110?)
	To Chalk	295 (or 300?)
Chalk, with occasional layers of flints		130 or 150
		425 or 450

FAIRSTED.—W.N.W. of Witham, (*a*) 300 yards S.S.E. of the Rectory; (*b*) Troys Hall (eastward of the Church.)

Information from Mr. J. HATLEY.

	a. Feet.	*b.* Feet.
Boulder Clay	16	60
Gravel	—	1½
London Clay	260	290 or 300
To sand	276	360 ?

FEERING.—Two wells on the high road.

From the well-sinkers.—W. H .D.

	Valley Gravel. Feet.	Boulder Clay to Sand. Feet.
1. Gore Pit	20	About 30
2. House at lane to village just N.E. of Gore Pit. About 120 feet above Ordnance datum	10	30

GOSFIELD.—Park Hall; a mile W. of the Church (westward of Halstead).

Information from MR. J. HATLEY.

Water rose to about 20 feet below the surface.

Drift and London Clay, to sand and water 140 feet.

GREAT CANFIELD.—Bullocks Farm.

		Feet.
Boulder Clay and gravel	about	40
London Clay	„	130
Mottled sand [Reading Beds] with water	„	5
		175

GREAT HALLINGBURY.—Harp's Farm.

Information from Mr. G. INGOLD.

Brown, blue, and black clay	128 Feet.
Sand	

GREAT HALLINGBURY. START HILL.—Tile Kiln Cottage.

	Feet.
Brown clay	25
Black sandy loam	35
	60

HALSTEAD.—Waterworks, at N.E. end of the town. About 1860.

From a drawing in the office of the Local Board.

215 feet above high water-mark (Essex Coast).
Shaft 140 feet, the rest bored.
Water rises to 90 feet below the surface, supply abundant.

			Feet.
Soil			over 5
Marl [? Boulder Clay], with gravel at bottom, on one side only (2 feet)			nearly 40
[London Clay, 83 feet ?]	Blue clay		over 65
	Rock	[? basement-bed]	nearly 10
	Brown sand		over 5
	Blue clay		3
[Reading Beds, 65 feet ?]	Sand		2
	Dark sand with clay		nearly 20
	Plastic clay		15
	Green sand		over 23
	Dark black sand		nearly 2
	Pebbles		2
[Thanet Sand, 38 feet ?]	Dark sand and clay		over 33
	Light-coloured clay		nearly 5
		To Chalk	230
Chalk			100
			330

[The division between the London Clay and the Reading Beds is hard to make out and may be lower.]

HALSTEAD.—Ashfield Lodge.

Information from Mr. J. HATLEY.

	Feet.
Boulder Clay	20
Sand, the upper 40 feet dry, the rest wet	70
London Clay	70
To sand	160

HATFIELD BROAD OAK.—4 miles eastward of Sawbridgeworth, S. end of the Green. 1869. 3½ feet of water.

From observation. W. H. P.

		Feet.
Glacial Drift.	Dark grey Boulder Clay	65
	Sharp light-coloured sand, with small pebbles of quartz and flint	3
		68

HATFIELD BROAD OAK.—The Grange.

Sunk and communicated by Mr. G. INGOLD.

	Feet.
White and blue Boulder Clay	70
Gravel	4
	74

HATFIELD HEATH.—The Brewery.

10 feet of water.

Two accounts, by

The Foreman at the Brewery.		Mr. Watson, Bishop Stortford.
6 or 7 feet.	Gravel and sand	20 feet
120 „	Clay	80 „
	Gravel or sand	
130		100

HOOD END.—"Thurston's" 2½ miles N.E. of Finchingfield.

Said to have gone through 140 feet of Boulder Clay.

KELVEDON.—Felix Hall.

Information from Mr. J. HATLEY.

Supply 18,000 gallons in 24 hours; water level about 28 feet down.

	Feet.
London Clay	130
Sand	2
Red Clay	30
To red sand	162

LITTLE HALLINGBURY.—Just W. of the Church.

From observation. W. H. P.

	Feet.
Gravel	15
Boulder Clay	40
Grey sand (water)	5
	60

PARNDON HALL.

Information from Mr. G. INGOLD.

	Feet.
Gravel	10
Boulder Clay	20
Gravel	12
Black clay	6
	48

QUENDON.

Gravel and sand, 80 feet.

Rickling Green (between Bishop's Stortford and Saffron Walden).

	Feet.
Boulder clay	25
Gravel and sand	35
Chalk	—
	—

Saffron Walden.

The following account of this well is from the "Essex Literary Journal," Feb. 15, 1839:—

"Artesian well at Saffron Walden, made in 1836.

"After passing through about 10 feet of gravel the Upper Chalk was reached, penetrating which, to the depth of 50 feet, a thin stratum of Oolite was found, lying in the Chalk, of 4 feet in thickness; the Chalk was again penetrated and entered to the depth of 275 feet, when a fine and strong spring was opened which rose to within 18 feet of the surface; this spring upon being pumped yielded about 40 gallons per minute without cessation. Wishing, however, to ascertain whether by boring lower a spring could not be reached which might flow over the surface, the operation was continued to the depth of 1,004 feet 4 inches, but the only stratum after passing the spring was chalk-marl, containing numerous shells with pyrites. No other spring was come to even at that great depth, and the soil appears to have varied but little for the last 700 feet.

"Samuel Purkiss was the borer, whose foreman, John Bell, did not during ten months quit the experiment for a single hour.

"The boring was at the expense of Jabez Gibson, Esq."

The above section should probably be thus divided:—

	Feet.
Gravel	10
Upper Chalk	40
Chalk-rock	4
Lower Chalk	221
Chalk Marl, Gault, Lower Greensand, Kimeridge Clay, and Oxford Clay	729
	1,004

The well-borer told me, in 1870, that the only spring reached was in *green sand*, and that there was blue clay at the bottom of the bore.—W. H. P.

Dr. J. Mitchell's MSS. (*see* p. 5) says, "Chalk 250 to 300 feet, with blue clay below," vol. ii., p. 102; but in vol. v., p. 67, "Chalk has been penetrated at Saffron Walden, and found there to be about 500 feet in thickness." Whilst this Memoir was in the press a note was read to the Norwich Geological Society on this well. *See* Part I. of that Society's *Proceedings*, p. 28.—W. W.

Saling.

Communicated by Mr. J. Brown, of Braintree.

Shaft 160 feet, the rest bored.
20 feet of water in the shaft.

		Feet.
[Glacial Drift, 75 feet.]	"Chalky Gault" [Boulder Clay]	12
	Dry sand and gravel	28
	Wet sand	35
London Clay		165
Reading Beds.	Plastic clay and green sand	30
	Dark clay and green sand	30
	To Chalk	300
Chalk		110
		410

SAWBRIDGEWORTH.—"Wallbury Camp."

Information from Mr. G. INGOLD.

Sand and gravel, 50 feet.

TERLING.—The Place.

Communicated by the late LORD RAYLEIGH.

Shaft 60 feet, bore about 200 feet.

Water rises into the shaft.

Gravel, sand, and loam to about 40 feet.

The rest London Clay, with rock [basement-bed?] pierced through at bottom.

THAXTED.—Near the Church.

	Feet.
Soil	4
Gravel	40
Blue clay	22
Quicksand (water)	4
	70

THAXTED, Cutler's Green, a mile W. of the town.

	Feet.
Boulder Clay	28½
Gravel	30
Blue clay	14
Quicksand (water)	4½
	77

TINDON END.—Two miles N.N.E. of Thaxted.

Water within 40 feet of surface.

Boulder clay to "Rock," said to be 140 feet.

WENDEN.—Mr. T. Collins', 200 yards E. of Audley End Railway Station.

Communicated by Mr. G. INGOLD, well-sinker.

Shaft 55 feet, the rest bored.

Slow spring. 8 to 9 feet of water in the shaft.

		Feet.
[Post-Glacial].	Gravel	10
[Glacial Drift, 210 feet.]	Fine laminated yellow sand	45
	Dark grey sand	165
	To Chalk	220
Chalk		50

Another account describes the bed above the Chalk as bluish clayey sand, and white marly stuff.

This is a remarkable section, as the Chalk comes *to the surface* within 100 yards in almost every direction.—W. H. P.

WICKEN BONNETT.—1. The Rectory. 2. Hall Farm.
Information from Mr. WATSON of Bishop's Stortford.

	1. Feet.	2. Feet.
Boulder Clay - - - - -	18	40
Gravel and sand - - - - -	20	20
To Chalk -	38	60

WITHAM.—Waterworks, on the left side of the Guith just below the high road. 1869.

From a drawing in the Literary Institution, Witham. (J. CHURCH, Engineer.)
Shaft 60 feet, the rest bored.

		Feet.
Mould and made ground		3
[Drift, 66 feet]	Coarse gravel	11½
	Silt	25½
	Clay with chalk and small flints [Boulder Clay]	29
[London Clay 154½ feet]	Sandy loam	2
	Blue clay	8
	Sandy loam	4
	Blue clay	7
	Sandy loam	2½
	Hard blue clay	6
	Silt clay and sand	12
	Hard blue clay	60
	Sandy loam	6
	Blue clay	47
[Reading Beds, 27 feet]	Blue clay full of small flints	20
	Black sand	4
	Blue Clay	3
[Thanet Sand, 24 feet]	Black sand	20½
	Green sand	3
	Flints	½
	To Chalk	274½
Chalk		225½
		500

WITHAM.—Chipping Hill. Woolpack Inn, north of the Churchyard.
Information from the sinker, Mr. J. CHALK.

	Feet.
Gravel	15 to 16
Boulder Clay	26
London Clay	75
Rock	½
To sand	117

WITHAM.—Powers Hall, more than a mile W.N.W. of the town.
Information from Mr. HATLEY.

Water rose to 44 feet below the surface.

		Feet.
[Glacial Drift]	Boulder Clay	20
	Sand and gravel	20
London Clay		210
	To sand and water	250

HERTFORDSHIRE.

AMWELL END.

Information from Mr. S. C. HOMERSHAM, C.E.

Shaft 49½ feet.

Water-level near the surface. Supply 1,694,880 gallons in 24 hours. (See W. C. Mylne, p. 651 of Evidence on Metropolitan Waterworks Bill, 1851.)

	Feet.
Gravel	over 18
Chalk with flints	about 80

(See also *Geological Survey Memoirs*, vol. iv. p. 447.)

AMWELL [? New River Co.]

Information from Mr. S. C. HOMERSHAM.

Shaft 91 feet (with galleries, 7½ feet high, at bottom), bore 47 feet; total 138 feet.

Supplies 2,458,080 gallons in 24 hours. (See as above.)

Water-level 27 feet down.

BISHOP STORTFORD.—Railway Station.

Information of this and the following wells in this town from Mr. G. INGOLD.

		Feet.
	Made earth	6
	Yellow loam	2
	Stiff brown and blue clay	4
	Gravel, with pebbles	8
[Reading Beds]	Loose sand and fine gravel	30
	Very stiff blue clay, with a large stone at the bottom	1
	Yellow loam	4½
	To Chalk	55½

BISHOP STORTFORD.—Gasworks and "Anchor" Malting.

Water within 4 feet of surface.

	Feet.
To Chalk	135
In ditto	25
	160

BISHOP STORTFORD.—Workhouse.

Water rose to 85 feet below the surface.

	Feet.
Boulder Clay	50
Gravel and sand	25
?	38
To Chalk	113
Chalk	80
	193

BISHOP STORTFORD.—200 yards south of the church.

	Feet.
Drift gravel	8
Brickearth [Reading Beds, and perhaps a little London Clay]	39
To Chalk	47

BISHOP STORTFORD.—Hockerill, "Crown" Yard.

	Feet.
Loam	10
Sand and gravel	20
Clay (? Tertiary)	30
To Chalk	60

BISHOP STORTFORD.—Hawkes and Co.'s Brewery.

Shaft 19 feet; the rest bored.

Water 9 feet in the shaft, pumping 108 gallons a minute lowers the water to 4½ feet, at which depth it remains.

To Chalk, about 50 feet.
Chalk, „ 149 „

FURNEAUX PELHAM.—The Brewery.

Loam and fine gravel to Chalk, 30 feet.

HADHAM.—East of Westfield Farm.

From observation. W. H. P.

		Feet.
Recent	Sandy wash	3
	Pebble-gravel, in dirty matrix	11
Reading Beds.	Loam	10
	To Chalk	24

LITTLE MUNDEN.—(J. Jollings, Esq.)

Sunk and communicated by Messrs. DOCWRA and SON.

Shaft 116 feet, the rest bored. Water about 112 feet down.

	Feet.
Surface-earth	1½
Chalk	144½
	146

PERRY'S GREEN.—North-east of Widford.

Good supply of water.

White Boulder Clay	23 feet.
Dark „ „	
Sand, &c.	

ROYSTON.—White Lion Inn, S. end of the town.

Chalk, 150 feet; water-level, 120 feet down.

ROYSTON.—1. Brewery. 2. Heath Farm.

Sunk and communicated by Mr. R. B. PATEN.

1. Shaft, 60 feet; boring, 105; total, 165, all chalk.
2. „ 250 „ ; „ 111; „ 361, „

STOCKING PELHAM.—Mr. Richardson's Cottages.

	Feet.
Boulder Clay	30
Sand	15
	45

SUFFOLK.

Chilton Street.—North of Clare.
Information obtained by Mr. **Jukes-Browne.**

	Feet.
Gravel	7
Blue clay (Boulder Clay)	35
A strong spring at	42

Clare.—Rev. W. B. **Clarke**, *Trans. Geol. Soc.*, ser. 2, vol. v. p. 375 (1840).

	Feet.
Diluvial [Boulder] clay with chalk-stones	126
Chalk	37
	163

Long Melford.—Railway Station.
From information on the spot. W. W.

Supply about 6,000 gallons a day.

			Feet.
[Glacial Drift]	Gravel and sand,	about	19
	Blue [Boulder] clay	„	28
			47

Stoke (by Clare)—Near the Railway Station.
From observation. W. H. P.

To Chalk, about 24 feet.
Water stands about 3 feet below the top of the Chalk.

Sudbury.—Waterworks, north of the town.
Communicated by Mr. T. **Hennell**, C.E. (And from information on the spot. W. W.)

Shaft about 70 feet, the rest bored
Water stands 17 feet up in the shaft, and is pumped down 8 feet.

		Feet.
Soil		4
Drift	Gravel	10
	Loam	20
	Blue clay with sand veins [some of this, lying about, is Boulder Clay]	37
	Crust of hardened sand	½
	Sand	1
	To Chalk	72½
Chalk		? 206
		278

APPENDIX 2.—BORINGS AND SHALLOW WELLS.

ESSEX.

WITHAM.—The Spa, three-quarters of a mile from the town, close to the avenue from Witham Place to the road to Faulkbourne.

J. TAVERNER.—"An Essay upon the Witham Spa," pp. 2–4, 1737.

The spring-head 12 feet lower than the ground around.

			Feet.
[Post-Glacial Drift]	Strong loam	about	4
	Strong loam with gravel	„	3
	Gravel	„	3
	Tough bed of lamellæ of different colours (2 in.)		
	Gravel with sand, not bottomed		4

3 Borings [along the Line of a proposed Railway]. Division 1, London to Cambridge. From a book of MS. borings in the Geological Survey Office.

No. 7. TAKELY.—At a point 16 chains south of the road from Brick End to Wood Farm.

		Feet.
[Boulder Clay]	Clay	4
	Blue clay, with small chalk, very hard	22

No. 8. DEBDEN.—At a point 49 chains north of the road to Sibley's Farm.

		Feet.
[Boulder Clay]	Clay	6
	Blue clay intermixed with chalk	29

No. 9. WIMBISH.—At a point 26 chains north of the road from Elder Street to Debden.

		Feet.
[Boulder Clay]	Clay intermixed with stones	9
	Blue clay intermixed with small stony chalk	41

HERTFORDSHIRE.

AMWELL END.—Three borings near the New River Company's well. Communicated by Messrs. T. DOCWRA and SON.

1. Nearest the New River.

	Feet.
Soil	3
Gravel and water	3
Large flints	1
Gravel and water	4
To Chalk	11
Loose Chalk	6

2. Middle one and nearest to the well.

	Feet.
Gravel	4
Gravel and water	2
Large flints	1
Gravel	6
Sandy loam	1
Shingle	5½
Chalk	½
Shingle	3
To Chalk	23
Loose Chalk	15

AMWELL END—*continued.*

3. Farthest from the New River.

	Feet.
Peat	3
Gravel and water	9
Sandy loam	1
Gravel	8
Shingle and vein of chalk	20
Sharp sand and vein of chalk	3
Shingle " " "	3
Shingle	3
To Chalk	50
Loose chalk and vein of flints	5
Chalk	16
	71

RIVER LEA NAVIGATION.

Communicated by Mr. N. BEARDMORE, C.E.

1. Hertford lock, on west of canal.

	Ft.	in.
Soil	2	8
[Alluvium] Clay	0	7
Peat	1	2
Gravel	18	1
To Chalk	22	6
Soft Chalk	7	11

2. Mill lock and black ditch on west of canal.

Soil	2	8
[Alluvium] Clay	0	10
Peat	0	8
Gravel	15	4
To Chalk	19	6
Soft Chalk	12	3

3. New lock and bridge, eastward of Amwell on west of canal.

Soil	2	6
[Alluvium] Clay	1	9
Peat	4	3
Gravel	11	4
To Chalk	19	10
Soft Chalk	12	6

4. Between Feildes weir lock and crossing of railway on west of canal.

Soil	0	6
[Alluvium] Loose clay	9	2
Peat	4	10
Gravel	15	6

Rye House.

Borings made and communicated by Messrs. T. Docwra and Son.

1.

		Feet.
Soil		1
[Valley Drift, 14 feet]	Loam	2
	Rough gravel	2
	Loose gravel with water	1
	Brown sand	8
	Flints	1
	To Chalk	15

2.

Soil		1
Gravel		8
To Chalk		9

Rye House Bridge, 1853?

Soil		1
[Valley Drift, 18 feet]	Dark loam	1
	Light-coloured loam	4
	Light-coloured gravel	4
	Red gravel, full of water	6
	Hard rough gravel	3
[?Woolwich & Reading Beds 10 feet]	Light green sand	4
	Plastic clay	3
	Green sand	3
	To Chalk	29
Chalk		1

Hole near water-cress bed.

Soil		2½
[Valley Drift]	Dark loam	1
	Rough bright gravel	3½
[? Woolwich and Reading Beds, 13 feet]	Plastic clay	1
	Brown sand	1
	Light-coloured sand	5
	Green sand and pebbles	1
	Brown sand	5
	To Chalk	20

Ware Marshes.—By Balance Engine (River Lea).

Borings made and communicated by Messrs. T. Docwra and Son.

No. 1 showed only the same thickness and kind of alluvial beds over gravel as No. 2.

No. 2.

		Feet.
[Alluvium]	Yellow clay	3
	Peat	4
[Valley Drift]	Bright gravel	8
	Sandy gravel	4
	Rough gravel	2
	To solid Chalk	21

WARE MARSHES—*continued.*

No. 3.

		Feet.
Top soil		1
?	Loam	9
	Yellow clay	10
	Blue clay	12
	Brown sand	6
	Sand and black pebbles	14
	Brown sand with water, chiefly at bottom part	20
	To Chalk	72

[This last looks like a boring through London Clay and Lower London Tertiaries.]

SUFFOLK.

SUDBURY (for the waterworks).

Communicated by Mr. T. HENNELL, C.E.

1. By the high road, westward of the waterworks.

			Feet.
Soil			2
[Post-Glacial Drift]	Loam		6
	Sandy loam		10
	Gravel		8
	To Chalk		26
Chalk		about	12

2. By new road, south-westward of the waterworks.

			Feet.
Soil			2
[Drift]	Loam and Chalk		3
	Brown sand		2
	Loam		2
	Brown loam		15
	To Chalk		24
Chalk		about	20

POSTSCRIPT.

The following well-section came to hand whilst this Memoir was in the press. W. W.

WICKHAM BISHOP.—Site of Second Essex Asylum, Heathgate Farm, S. of Chancery Wood, 1878.

Sunk and communicated by Messrs. EASTON and ANDERSON. Also from information from the foreman, and from specimens collected by Mr. J. B. JORDAN.

About 240 feet above Ordnance Datum.

Shaft and cylinders throughout.

Dip about 18 inches in the outer diameter of the well (about 8 feet), to the west.

			Feet.
Surface soil		about	2
[Drift,]	Yellow clay	„	11
	Sand and gravel, with surface-springs		30
[London Clay, 262 feet.]	Blue and black clay with septaria and iron-pyrites (stems of plants). Some specimens of septaria with *Rostellaria* and bivalves		232
	Running sand and septaria, with a strong spring of salt ferruginous calcareous water*		20
	Black pebbles		¼
[Reading Beds.]	Hard mottled blue and grey sand and clay		2½
	Red and blue mottled clay; brown and grey mottled clayey sand [specimen] at the bottom		2¼
			300

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* Mr. H. G. Dixon tells me that there were many fragments of shells in this sand, but too fragile for identification.—W. H. D.

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OF

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